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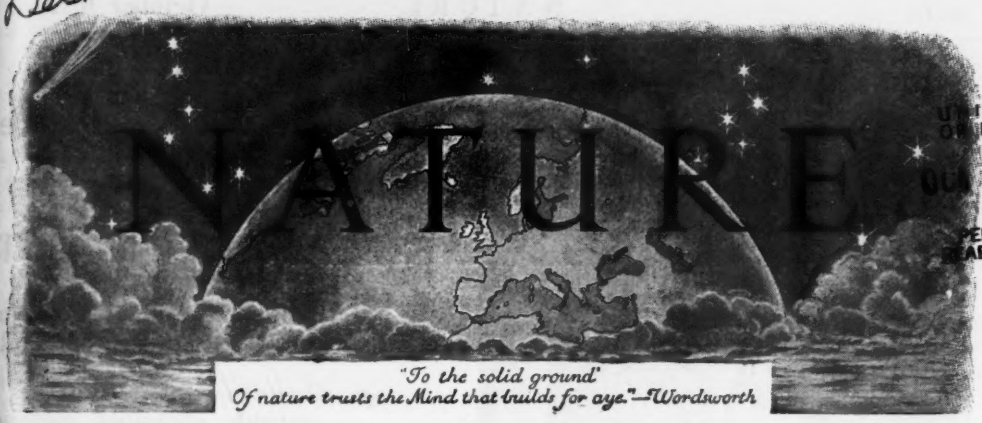

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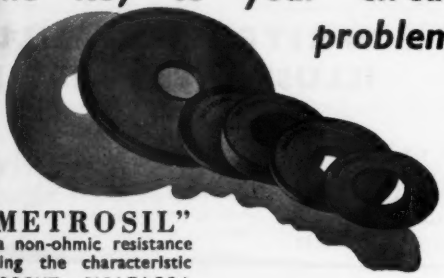

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ATOMIC ENERGY AND THE BALANCE OF SCIENTIFIC EFFORT IN BRITAIN

IN its first annual report, the United Kingdom Atomic Energy Authority set in the forefront its difficulties in recruiting sufficient scientists and technologists to permit the due execution of its civil and military programmes. It recognized that this situation was only one aspect of the national shortage of technological skill. Less is said in its second report (see p. 717 of this issue) about the staff position, though the recruitment difficulties have not entirely disappeared. The problem presents itself rather as one of the distribution of resources of trained man-power or of the balance of research effort in Britain, and this aspect is the more important with the great increase of interest in the development of nuclear energy as a source of power and in the independent activity of industrial firms in the field of nuclear energy which has marked the past year or so.

In view of the importance of the staff position, it is disappointing to find such slight indication in the report of the magnitude of the Authority's demand for skilled man-power. The figures given show that non-industrial staff increased by some 30 per cent during the year and the industrial staff by 13·6 per cent; but we are not told what proportion of the 10,795 non-industrial staff or 13,178 industrial employees represents technicians or what scientists or technologists. Nor, again, does the report give an idea of the magnitude of the research effort for which the Authority is responsible, even of that which is entered as fundamental research to be charged to the Exchequer; though it is true that the chapters of the report dealing with technical developments and research and development as well as reactor technology make it clear how wide and varied are the Authority's demands for scientists and technologists, and the many fields of knowledge which its research programme involves.

Nor is what little is disclosed about the staff position entirely reassuring. Some 88 per cent of the non-industrial staff taken over had accepted offers of employment when the lists were closed in February 1956, and three-quarters of the Civil servants who had decided against joining the Authority's staff had been released by March 31, 1956; 91 per cent of the industrial staff seconded from the Department of Atomic Energy or taken over from other government departments accepted offers of employment with the Authority. Nevertheless, the expansion during the year was only achieved by an intensive recruitment drive, and although this was reasonably successful in the middle and lower ranges of staff, difficulty continued to be experienced, particularly in the engineering field, in filling the more senior posts.

It may be surmised that, with the considerable advance in the removal of security restrictions from information on nuclear energy emphasized in the report, security considerations will be a factor of diminishing importance in recruitment, though such considerations are likely to be relevant in the appointment of senior staff. There has been, indeed, in general an encouraging desire to enter the nuclear energy field, and a fair supply of candidates for senior posts. Only a small proportion, however, were of the high standard required in this pioneering sphere; and, with the increased activity of private industry in nuclear power development, the Authority has lost a small number of experienced staff to firms entering this field. However, unless the Authority continues to act to some extent as a training ground for industry in this field, its demands for scientific and technical man-power might be viewed with more misgiving. When the Lord President of the Council addressed the Parliamentary and Scientific Committee on nuclear energy on June 13, Dr. G. E. Foxwell and Sir Andrew Bryan expressed anxiety as to the effect of the magnitude of the research effort of Britain in the field of nuclear energy on research in other directions; but Lord Salisbury in his reply did not wholly succeed in removing concern as to the balance of research effort.

What is disturbing in the present report is the magnitude of the effort going into the Authority's recruitment campaign. More than 52,000 applications for non-industrial employment were received during the year, and more than 12,000 candidates were interviewed. Even assuming that these figures relate to the total increase (almost 2,500) in such staff, they represent a considerable tax on man-power in themselves, which it should be worth some trouble to reduce or eliminate.

The report shows that the Authority is fully aware of the wider implications of its activities. It is considering what expansion should be made in its training facilities, particularly for scientific and technical staff, in the light of the White Paper on Technical Education. The Authority is, of course, already through its Isotope School, its Reactor School, and its programme of training for staff from the four industrial teams noted in its first annual report, an important source of technical training in this special field. While this can never represent in magnitude more than a minor but important feature of the Authority's activities, the report shows clearly the value of this contribution to the spread of knowledge and technique in this field. Up to and including the first course in 1956, 199 full-time and 100 part-time students have passed through the Reactor School, while, internally, bursaries are awarded to members of the staff for full-time university education; experiments were made with 'sandwich courses' in which training in a technical college alternates with periods of practical experience in the Authority's establishments, and nine graduates were recruited in 1955 to the scheme for postgraduate apprenticeship.

These figures may seem small; but they represent an important consideration to be taken into account against the Authority's demand for trained man-

power, if that were known. The Authority's staff has also made important contributions to technological education in universities, polytechnics and technical colleges by assisting with lecture courses in the nuclear sciences; and specialized lectures have been given to learned societies. Apart from the question whether the Authority is yet doing all that is reasonably possible in these directions—and doing it in the most effective way—it should be noted that the remoteness of most of the Authority's establishments has not prevented such work. Moreover, as the magnitude of the sales of radioactive isotopes both by the Radiochemical Centre and the Isotope Division of the Atomic Energy Research Establishment alone shows, the Authority is itself an industrial undertaking on a considerable scale. Its Industrial Group operates factories, and its participation in technical education thus demonstrates the practicability of the co-operation of industry in technical education in the way in which the Minister of Education has suggested.

There is, however, another related factor to be considered in this connexion to which also the present report directs attention. The Reactor School at Harwell is not simply a technical educational institution. It is an important vehicle for the dissemination of information. The development of nuclear energy in the United Kingdom has led to a situation in which the great bulk of the scientific and technical knowledge has been concentrated in the Atomic Energy Authority and, as the report emphasizes, it is imperative that this knowledge be disseminated if industry is to play its full part in exploiting the commercial applications of nuclear energy.

The Reactor School is one such means. Others described in the report include the issue of a monthly list of unclassified documents, copies of which are supplied to seven 'depository' libraries, in which the documents are freely available to the public, and access agreements with individual firms. The Authority is prepared to enter into such agreements on conditions which ensure that the Authority secures some financial return for commercially valuable information or for the use of patents owned by the Authority, and that firms are not enabled to use the Authority's assistance to build up exclusive rights for themselves. The subject-matter to which access is given must be carefully defined, on the basis of a demonstrated 'need to know', and the firm must observe the security precautions specified by the Authority. Access may be by means of receiving classified reports, or by visits to the Authority's establishments, or—more rarely—by the attachment of staff or secondment from firms to the Authority's establishments for defined periods. Although the Authority can only provide limited facilities in this way, more than a hundred scientists and engineers from British firms were attached to the Authority's establishments at the end of the year under appropriate agreements.

These agreements have proved to be advantageous both to the firms and to the Authority, because attached staff have worked as members of the appropriate research teams and have often made substantial contributions to the work of the Authority. The importance of this method of disseminating information is further illustrated by the new industrial projects to which reference is made in the report. The firm of Associated Electrical Industries, Ltd., for example, is to construct the first privately owned reactor in the United Kingdom, for which the Authority will provide enriched fuel elements on loan terms, and it is understood that in addition to using the reactor for its own long-term research in physics and engineering, and for training its own staff, the Company intends to make it available to universities for graduate and postgraduate training in nuclear science and technology. Two new major groups have entered the nuclear field during the year: Vickers Nuclear Engineering, Ltd., formed by Vickers, Ltd., Rolls Royce, Ltd., and Foster Wheeler, Ltd., are considering the application of nuclear energy in marine propulsion, and the Hawker-Siddeley Nuclear Power Co., Ltd., is initially studying the application of liquid-metal-fuelled reactor systems.

In these circumstances, the dissemination of information should be as efficient as possible and should not be impeded by secrecy considerations unless they can be fully justified. The Geneva Conference last year demonstrated that a high price can be paid for secrecy with no advantage in security. This aspect requires continual re-examination, for although the attitude of the Authority as indicated by this report is reassuring, in practice it could easily happen that information remained classified long after there was any sound reason for it being kept secret. The very scale of the operations of the Authority disclosed by this report makes it essential in the national interest that there should be the widest possible discussion of the complex questions involved. Even now the information is not being supplied which will permit realistic and responsible discussion of such issues as the balance of our research effort, the distribution of man-power and the relation of Britain's effort in the development of nuclear energy to her export trade and to the Colonial development and other assistance she is providing to the more backward countries under the Colombo Plan and in other ways.

The Atomic Energy Authority clearly has enlightened views on such matters; but it was scarcely to be expected that its report would throw much light on the relations of Britain to the proposals for closer European co-operation in the nuclear energy field, whether through the Organization for European Economic Co-operation or Euratom. Its judgment, however, as to the development of export trade in nuclear reactors could well be wrong, and while orders from overseas are likely to follow rather than precede the achievement of nuclear power on a competitive basis in Britain, the demand may well represent a significant part of the total value of the engineering industry's exports earlier than the Authority expects. The Authority could easily under-estimate the capacity of the engineering industry for development in a new field, given the

information and facilities which the industry itself, and not some outside body, judges to be essential.

It is at this point that the attitude of the Government becomes important. It is known that Britain is reluctant to co-operate fully in the European Atomic Agency which the Council of the Organization for European Economic Co-operation decided on July 18 in Paris to establish. Questioned in the House of Commons on July 31, the Chancellor of the Exchequer said that it is too early to define the extent of United Kingdom participation in the Agency, but that the United Kingdom will play a full part in the steering committee which is to draft a statute for the Agency. From what Sir Edward Boyle, Financial Secretary to the Treasury, said in Paris, it appears that, while Britain is prepared to place its technical knowledge and experience at the disposal of the Agency, the Government is nervous of the supra-national authority which the new agency will probably possess eventually, and reluctant to commit itself to full participation.

Obviously, co-operation in the field of nuclear energy has implications for European co-operation generally, and participation might involve great difficulties due to commitments in the Commonwealth. A negative attitude, however, has its own drawbacks; and although the British Government hesitates with reason to participate in the Euratom project, in which the proposals for a supra-national nuclear energy pool may well involve a degree of control over civil and military uses of nuclear energy beyond what Britain could accept, it is nevertheless essential to give full support to the more limited project for a nuclear energy agency, the main purpose of which is to facilitate joint undertakings among member countries. At the least, if the Government is not prepared to participate fully, it should give clear and convincing reasons for its reluctance.

The Atomic Energy Authority's second annual report does nothing to remove the impression that over the whole field of nuclear energy the Government is lacking in imagination. This is true no less in regard to European co-operation than in regard to secrecy. Just as it may well be disastrous to Britain to be left out when European co-operation in the nuclear energy field gets well under way, so lack of imagination in regard to policies of secrecy and regulations could well frustrate the promising developments in industry to which the report refers. The Authority itself is well aware of the importance of enterprise and imagination in activities dependent largely on experimental science; but that very factor should emphasize that the Authority is not necessarily the best judge of the worth of an experiment elsewhere, or of the needs of a firm for some particular piece of information.

This is not to suggest that the present organization of the Authority itself is not reasonably sound and adapted to its purpose. So far as can be judged, it possesses the freedom of operation and the flexibility which are so important in a field where initiative and experiment are vital, as well as readiness to modify plans as the tempo of development increases or new possibilities emerge. It is at the top, or rather outside the Authority, that doubts exist. As Mr. R. Davey Best points out in a survey of the organization of the Authority in *Public Administration*, very large responsibilities are placed on the Lord President of the Council in relation to the Authority; but the Lord President still has only a very small office to enable him to discharge these and other functions. It is here that the Government appears to be lacking in imagination and foresight. As Lord Salisbury himself said in the House of Lords on December 14, 1953, the Lord President is concerned with main questions of policy, and in particular, the balance of use of nuclear material between the needs of defence, power, biology and so on, so as to ensure that the broad needs of government policy and the broad needs of the country are satisfied. He is also generally responsible for the Government's contact with the world of science and technology and is in a position to be impartial between the different users of nuclear material. Lord Salisbury's address to the Parliamentary and Scientific Committee showed how admirably qualified he is for this vital post, that he appreciates fully the need for flexibility and that decision, for example, between the various types of reactor to be selected for nuclear power stations depends on the considerable research experience now being acquired by the Authority, or, again, the importance of public confidence in the experts working in such fields. This very suitability, however, tends to obscure the importance of two points: first, the necessity for the Lord President to be supported by an adequate staff to enable him to discharge adequately and flexibly his heavy responsibilities for promoting a reasonable balance in the research effort of Britain and the supply and distribution of its trained man-power; and secondly, the need for a direct spokesman of his office in the House of Commons. The very reasons that to-day in practice require the Chancellor of the Exchequer to be a member of the House of Commons demand no less insistently that there should be in the House of Commons a member of the Cabinet who can speak directly and from first-hand knowledge on Government decisions and policy in regard to scientific and technical effort, and who can satisfy Parliament that the great opportunities which nuclear energy has brought about are being fully explored and used with vision, enterprise and decision.

THEORY OF FLOWING WATER AND SILT

An Introduction to Fluvial Hydraulics

By Serge Leliavsky. Pp. xii+257. (London: Constable and Co., Ltd., 1955.) 30*s*. net.

THIS short book by a distinguished expert in river hydraulics is an excellent summary of the various theories, methods and facts bearing upon the flow of water in erodible channels, which are themselves the natural creations of this flow. The current which erodes such a channel is in turn controlled by the ever-changing shape of the channel it has eroded; hence, we are faced here with a problem of successive

approximation which converges either to the stable or equilibrium channel of canals and some rivers, or to the fluctuating pattern characteristic of meandering rivers and shifting estuarine channels. Much work has been done, and some progress made, with the equilibrium shape of stable channels transporting both water and silt; but the problem of meandering channels under natural conditions has received less attention, and the causes and factors which control the size and sinuosity of the meanders are still a matter of conjecture.

As might be anticipated, in a field in which active investigation is at the moment being pursued and in which new ideas are constantly being put forward and older theories revised, the historical treatment has much to recommend it. This is the treatment followed in the book, and the author has performed a valuable service in directing attention to much that is suggestive and thought-provoking in the works of earlier engineers. In particular, river engineers will be grateful for the exposition of the rationale and art of river training practised by earlier engineers, which are not widely known and which can still be scarcely improved upon. Also, those concerned with hydraulic models of meandering rivers would do well to ponder the criteria for similitude given by earlier workers—it is clear that attention to earlier laboratory results would have rendered unnecessary a good deal of later experimentation on similar lines.

The basic property of fluvial hydraulics calling for study is the capacity of flowing water to transport from place to place solid particles of greater density than the water itself. In reviewing the numerous attempts at this problem, two distinct lines of inquiry can be traced. While French, German and American research aimed at finding the forces and other mechanical factors acting on the particles individually and so coming eventually to an explanation of the behaviour of the system, the second school, including mainly Anglo-Indian and some Austrian engineers, attempted a study of the macroscopic properties of the system under the simplest conditions—that is, in 'silt-stable' canals and rivers, which neither silted nor scoured over a long period of years. By measuring the dimensions and discharges of such channels, they derived empirical formulæ, correlating the capacity of the stream to transport silt and sand with its main hydraulic characteristics. These formulæ were then used for the design of new canals and proved reasonably satisfactory. While it may appear that the second school cannot achieve great depth of insight into the basic mechanism of transport, it is nevertheless a fact that thus far it is this school which has provided the engineer with reliable design criteria. In fact, although several interesting and possibly significant attempts at practical solutions have been produced by the first school, none of them has yet achieved as wide and universal recognition as those of the second school.

The usual treatment of particle transport by a stream recognizes three different modes of movement: rolling and sliding along the bed; saltation or motion in short hops; and suspension. Unfortunately, the movement of particles along the bed of a stream is complicated by the presence of small-scale ripples as well as the large-scale dunes and shoals. These occur over a wide range of flow conditions in Nature, their size depending on the size of the bed material as well as the hydraulic factors. So far, very little progress has been made with a detailed explanation of the reason for the existence of such ripples. The tendency in the theories and analyses which have been framed to express bed movement has been either to leave rippling out of account or to force it into the background by incorporating disposable factors the value of which must be determined by experiment. This lack of an adequate theory of rippling also has adverse repercussions on the investigations of saltation and suspension. For the material travelling in this way has been taken from the bed by eddies generated by the ripples which may take particles directly into suspension in the manner of a whirlwind or, by sweeping them from the crests of the ripples, start them into saltation. It is perhaps significant that the existing theory of turbulent suspension becomes obscure and unsatisfactory near the bed, where ripples become a dominant feature. There is no doubt that, whatever progress may be achieved in the future in this branch of physical science, our knowledge will remain incomplete and empirical so long as this particular phenomenon remains unexplained in terms of mechanical theory.

G. H. Lean

FROTH FLOTATION OF MINERALS

Principles of Flotation

By Dr. K. L. Sutherland and Dr. I. W. Wark. Pp. xv+489. (Melbourne: Australasian Institute of Mining and Metallurgy (Inc.), 1955.) n.p.

THIS is a revised and enlarged edition of Dr. I. W. Wark's "Principles of Flotation" published in 1938. It is to be welcomed, for there have been considerable advances in the knowledge of the principles of froth flotation of minerals during the past twenty years; and during that period the process of froth flotation has been used much more extensively than before in mineral processing. Sutherland and Wark and their co-workers have made noteworthy contributions to our knowledge of flotation; it is inevitable that they should draw freely on their own results and on those of their colleagues. Their results, many of which are given in detail, are carefully discussed and compared with those of other workers; and, although it is not the intention of the book to deal with the technology of flotation, the bearing of the results on the practice of flotation is made clear.

The flotation process is influenced by many variable factors; indeed, a froth flotation cell in operation presents a very complex system because of the interactions between certain of the variables, some of which cannot readily be controlled by the operator. In their book, Sutherland and Wark deal with some of the important factors, but they are chiefly concerned with the action of the four groups of flotation reagents—collectors, frothers, activators and depressants—and the underlying principles of their roles in flotation. The most important chapters are concerned with the variables of flotation, physical principles, adsorption, experimental methods, flotation of sulphide minerals by collectors of the xanthate type, depressants, activation, joint effect of depressant and activator, flotation of superficially oxidized sulphide minerals, paraffin chain salts as collectors (about one-quarter of the book), kinetics of the flotation process, colloids and slimes in flotation, electrical properties of surfaces in relation to flotation, and frothing. The text is supported by a biblio-

graphy of nearly six hundred references; this is not, and is not intended to be, exhaustive, but each reference mentioned is touched on in the text. It indicates the careful consideration given by the authors to available results.

It should be emphasized that this book is concerned with principles and not with practice. There are no descriptions of flotation machines or flotation plants, although certain types of machine are referred to in the chapter on kinetics. The treatment of many specific minerals by froth flotation is mentioned, but it is surprising that the froth flotation of coal, which is becoming more and more important in the preparation of coal, is not mentioned (except incidentally in connexion with the adhesion of bubble to mineral).

The book is well written and well produced. There are few errors or misprints, but the error in definition of Reynolds's number given at the foot of p. 363 should not have escaped detection when the proofs were checked. The indexes are very good. This is an outstanding book, not suitable for the beginner but of considerable value to the advanced student, the research worker and the inquiring operator of the flotation process and, not least, to the teacher.

S. G. WARD

THE POLAR AURORA

The Polar Aurora

By Prof. Carl Størmer. (International Monographs on Radio.) Pp. xvii+403+34 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 55*s*. net.

IT would be presumptuous to attempt to 'review' the present volume by Prof. Carl Størmer on the polar aurora—a field of study which he has truly made his own. At an advanced age he has collected together in book form the greater part of his researches on the observations and interpretation of the aurora. Everyone interested in this fascinating phenomenon will be greatly indebted to him, not only because, as he reminds us in the preface, his long series of papers on the subject is difficult to obtain in complete form, but also because of the invaluable and extensive theoretical investigations which the book contains.

On several occasions Prof. Størmer has related how his interests were diverted from the field of pure mathematics by the striking experiments carried out by his compatriot Birkeland on the deflexion of cathode rays in the field of a uniformly magnetized sphere. His great mathematical skill served him well in discussing the idealized, but nevertheless difficult problem of the motion of a charged particle in the field of a magnetic dipole with which he sought to illustrate the results of Birkeland's experiments. The great variety of orbits possible, beautifully illustrated by many plates in the book, is testimony to the infinite patience of the man who pursued the laborious calculations involved. These theoretical investigations, which form the second part of the book, were primarily intended as a contribution to the corpuscular theory of the aurora in the form proposed by Birkeland. The trajectories derived by Størmer indeed showed many analogies with the forms of the aurora, and though the neglect of the mutual interaction between the corpuscles in the stream makes the bearing on auroral theory uncertain, it is most gratifying that the theory has found a secure place in the interpretation of the global incidence of cosmic rays.

The first part of the book is concerned with the observation, forms, height measurement and spectroscopy of the aurora and also with its close connexion with geomagnetism. Our present knowledge about the position of the aurora in space is indeed almost entirely due to the photographic measurements of Størmer and Vegard; the methods used as well as the results they obtained are extensively described, as are also the geographical distribution and the methods of observing and photographing the aurora. Here will also be found an account of Størmer's important discovery of sunlit auroræ and of their intensity and colour. Other chapters are devoted to the auroral spectrum, auroral radio wave emission and radio echoes from the aurora. The author also considers such questions as the possibility of the existence of electrical currents outside the Earth's atmosphere, reviews the spectroscopic evidence for a solar corpuscular stream between the Sun and the Earth and considers the absorption of corpuscular radiation in the atmosphere and the emission of electric corpuscles from the Sun.

Though the accent in the theoretical parts lies on the Birkeland–Størmer theory of the aurora, brief accounts of other theories are given; and perhaps because in this field one is too apt to indulge in speculations, Prof. Størmer has kept almost entirely to verifiable facts. Thus, though it is generally believed that magnetic storms and auroræ are due to solar corpuscular streams, the evidence so far has been indirect and not entirely unassailable. The detection of hydrogen lines in the spectrum of the aurora by Vegard, Gartlain and Meinel clearly points to the entry of protons in the atmosphere. Nevertheless, as Størmer seems to imply, definite evidence that these originate from the Sun is perhaps still not definite.

The book is very well produced and the typography excellent.

V. C. A. FERRARO

NUCLEAR POWER ENGINEERING

Thermal Power from Nuclear Reactors

By Dr. A. Stanley and Oliver E. Rodgers. Pp. xiii+229. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 7.25 dollars; 58*s*. net.

A MECHANICAL engineer, noting the title of this book and reading the introductory remarks on the jacket, might expect to find a work designed to give him an idea of the special difficulties associated with the design of a nuclear power plant. If so, he would be disappointed. He would, perhaps, be surprised to find nearly one-third of it devoted to an elementary treatment of familiar topics such as thermal stress in isotropic elastic solids, laminar and turbulent pipe flow and convective heat transfer. Very little space is devoted to the fundamentals of topics such as thermal stress in non-isotropic and plastic materials, thermal shock, and transient heat transfer, which have increased in importance since the advent of nuclear power, and which are less familiar to the non-nuclear engineer. No literature references to specialist papers are given.

In restricting themselves to fundamentals, the authors have avoided dealing with any particular reactor system. This is a pity, since only by so

doing can the real engineering difficulties, the necessity for special materials and the economic incentives for high heat release-rates, be brought out. Although the choice of engineering topics is in question, those chosen are dealt with in a very elegant and satisfying manner. The text is concise and enjoyable, and the layout of the equations admirable.

The chapter on the reactor equations is particularly interesting, since slowing down and diffusion theories are dealt with in an unusual manner. The treatment has the great merit of uniformity and coherence, and teachers of this subject would do well to study it. The approach is direct and does not involve the use of such concepts as laboratory and centre-of-mass reference frames, buckling or reactor Laplacian. Dimensional analysis is applied to yield some interesting parameters, and a section is included on numerical methods. No treatment is given of fine-structure effects in natural or low-enrichment reactors. The value of this chapter to the engineer would be greatly improved if a comparison with experiment were provided.

There are two chapters on kinetics and shielding respectively. In the latter only basic principles are dealt with, and no design information is given.

In general, what has been done has been well done; but the whole book does not, in my opinion, justify the description given on the jacket. If the authors could be persuaded to write a book on reactor theory, expanding the treatment given in the present book, and dealing at greater length with numerical methods, a very useful work would result.

W. Murgatroyd

HUSSERL'S 'FIRST PHILOSOPHY'

Edmund Husserl

Erste Philosophie (1923/24). Erster Teil: Kritische Ideengeschichte. Herausgegeben von Rudolf Boehm. (Husserliana, Band 7.) Pp. xxxiv+468. (The Hague: Martinus Nijhoff; London: B. T. Batsford, Ltd., 1956.) 26.25 guilders; 52*s.* 6*d.*

THIS, the latest addition to the series of 'Husserliana' to be issued from Louvain, is of exceptional importance in that it bridges the gap between 1913, when Husserl's "Ideen" appeared, and 1928, which year witnessed the advent of his "Formalen und transcendentalen Logik". In 1923–24, however, the master had delivered his great course on a 'First Philosophy' at the University of Freiberg-im-Breisgau, and it is the historical content of these lectures which is now before us. His treatment of the classic problem of phenomenological reduction is reserved for the next volume, to be published in due course.

The structure of the present work is tripartite. First comes an examination of the whole field from Plato to Descartes. This is followed by a close scrutiny of the initiation by Locke of an attempt in egology, and of the questions which such studies have generated. Then Husserl traces in minute detail the development of sceptical prototypes of phenomenology by Berkeley and Hume, followed by the rise of dogmatic rationalism. These highly specialized sections are rounded off by a large number of appendixes, together with some subsidiary remarks concerned, for the most part, with textual criticism.

Taking these main divisions in order, Husserl is at great pains to stress (what of course is well known and appreciated historically) the accidental character of the term 'metaphysics', in its Aristotelian setting, and to fasten upon 'first philosophy'—which incidentally was very nearly equivalent to theology—as the potent phrase for the gradual build-up towards a conscious phenomenological system in the West. The claim to do this is made not only to avoid the vagueness inherent in any structure of metaphysics, but also and more positively to establish a discipline of first philosophy as basic for all science. This pattern of thought excludes the possibility of switching over at any period in history from concepts which are fundamentally devoid of scientific content to those of scientific value. In a word, the world of thought must begin how it means to go on. That it has not always consistently done so is probably a major factor in the recurrent crises (judgments) in European civilization, each one carrying the risk of a retrogression into barbarism. Yet phenomenology —as first philosophy—is closer to theology than some of Husserl's followers might always be ready to grant. He speaks of a 'philosophia perennis' in terms not altogether different from those of St. Thomas Aquinas.

In considering the period leading on to Locke's stress upon "actions of our own minds", the distinction between the empirical ego and the pure ego is important. The former concept is that of a number of conscious acts of which the individual can become aware by immediate introspection. There is a connexion here with Hume's 'bundle' theory, according to which the self consists of an aggregate of dynamic states, continually changing in a way suggestive of a revival of the philosophy of Heraclitus. In contradistinction, the pure ego is non-empirical, and is more in the nature of an inference from any data obtained by introspection.

The basic claim of phenomenology lies close at hand, which is that observation is not so much 'straightforward' as reflective. The former is descriptive of objects *per se*, the latter of objects intentionally. The difference is significant because, as Samuel Alexander once declared, the whole force of æsthetic appreciation may reside in contemplation, that is, in the power to reflect upon things (even our own handiwork), rather than merely to use them.

Husserl pays gracious and generous tribute, in the section dealing with phenomenological prototypes, to the genius of Berkeley regarding the influence which his pattern of thought has had upon the modern empirical theory of knowledge. His was, in fact, the first systematic attempt to make the world as we know it—as viewed subjectively—theoretically comprehensible. The misinterpretation, however, of the problems of constitution arises primarily from a lack of insight into the immediate field of consciousness, as might be expected when the fundamental assumptions are naturalistic in character. Nevertheless, phenomenology as we perceive it in the twentieth century has developed from a variety of sources, metaphysical as well as empirical; and this is as it should be, so long as the former always connotes 'first philosophy', rather than its fortuitous positioning by Andronicus of Rhodes.

For the scientist, phenomenology is valuable in that it aims relentlessly at rigour, not merely as a discipline, but constructively by placing 'the matters themselves' at the centre of his mental image; and in so far as they are self-given, he may assuredly accept them as true knowledge.

F. I. G. Rawlins

Thorpe's Dictionary of Applied Chemistry

Fourth edition, revised and enlarged. Vol. 12: General Index. Pp. iv+187. (London: Longmans, Green and Co., Ltd., 1956.) 42*s*. net.

WITH the appearance of a general index, which forms the twelfth volume, the fourth edition of "Thorpe's Dictionary" is now complete. This harvest of chemical knowledge is safely in, and this is an opportunity to congratulate those who have helped in the gathering. Boswell reports himself as saying to the author of another dictionary: "You did not know what you was (*sic*) undertaking". To which the author replied: "Sir, I knew very well what I was undertaking—and very well how to do it—and have done it very well". No better summing-up can be found for "Thorpe's Dictionary".

It is fitting to recall those who have undertaken the editorial work during the past twenty years and so placed us in their debt. Sir Jocelyn Thorpe was one of the two first editors of the fourth edition and saw the first six volumes published. Next came an editorial board consisting of Sir Ian Heilbron, Prof. H. J. Emeléus, Prof. H. W. Melville and Sir Alexander Todd. The assistant editors were Drs. L. N. Owen and A. J. E. Welch. The central figure throughout was Dr. Martha Whiteley, who died this year at the age of eighty-eight (see *Nature*, June 30, p. 1202), and who was editor for the whole period, in addition to her work for earlier editions and supplements. It is peculiarly appropriate that Dr. Whiteley was able to pass the whole edition through for publication, including this index. *Finis coronat opus.*

R. P. LINSTEAD

Introduction to Reference Books

By A. D. Roberts. Third edition, revised. Pp. vii+237. (London: Library Association, 1956.) 16*s*. (12*s*. to L.A. Members).

THE first edition of this book was based on lectures given during the 1945–46 and 1946–47 sessions of the School of Librarianship at University College, London, and it remains designed essentially for those taking up a career as librarian. For the scientist it may well give a surprising revelation of the wealth of material which awaits him in any inquiry outside his special field; but although Mr. A. D. Roberts has a short chapter on the literature of special subjects, a chemist, physicist or engineer will be surprised at the absence of any mention of works to which he is wont to turn at the first introduction to the literature of his subject.

Mr. Roberts has his answers. He has sought to avoid compiling an enormous list of titles, and in his successive chapters—on encyclopædias, dictionaries, directories and other business publications, bibliographies, serials, indexing and abstracting services, current national bibliographies and bibliographies of books in print, bibliographies of older British books, directories of societies and institutions, government publications, bibliographical works of reference, and atlases and maps—he describes clearly the kinds of reference books available.

Surprise at any particular omission should accordingly be balanced against the clear picture of the material at his disposal which is set before the student; and it is probable that the student who conscientiously follows the guidance and hints which he is given will come across the particular works omitted if they are relevant to any particular inquiry on which he is engaged.

R. BRIGHTMAN

Vector Analysis

By Homer E. Newell, Jr. (International Series in Pure and Applied Mathematics.) Pp. xi+216. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 41*s*. 6*d*.

IN the first eight chapters of this book, vector calculus is developed from the elements to the operator ∇, the integral theorems of Gauss and Stokes, and the standard elementary work on vector fields. The treatment is geometrical in flavour, but analytical difficulties are not ignored; when they are not completely disposed of, the reader is warned of their existence, and indications of how they may be overcome are given. In the last three chapters, Mr. H. E. Newell has selected as his chief application, apart from some work on kinematics, an account of electromagnetic theory.

In the preface, Mr. Newell deplores the familiar fact that students "who have been exposed to a course in vector analysis" so seldom learn to think vectorially. The remedy, for the student of applied mathematics, is surely to be found in a thorough integration of theory and applications; each new step should be introduced as the answer to a demonstrable need, and should be buttressed immediately by varied and significant applications. In the present book, as in so many others, the new concepts often come in rather abruptly, and too much of the buttressing is left to the exercises for the reader.

Mr. Newell has many merits as an expositor, and it is therefore to be regretted that he has not given the fully integrated account which the young student of physics and engineering would find so valuable.

Lithium Aluminum Hydride in Organic Chemistry

By Prof. Vukić M. Mićović and Dr. Mihailo Lj. Mihailović. (Serbian Academy of Sciences Monographs. Vol. 237. Section for Natural Sciences and Mathematics, No. 9.) Pp. xi+193. (Beograd: Serbian Academy of Sciences, 1955.) 3 dollars.

THIS is an interesting account of the more important uses of lithium aluminium hydride, or, as the authors have it, lithium aluminum hydride. There are twenty-five chapters. Chapter 1 is concerned with the hydride as a reducing agent in organic chemistry, and Chapter 2 with its formation and properties. The next chapter deals with reactions of the hydride with inorganic and organometallic compounds, and Chapter 4 with its reactions with compounds containing active hydrogen. Then there is a chapter devoted to general experimental procedures, with notes on fire hazards and the like.

Chapters 7–24 cover the reactions of lithium aluminium hydride with compounds containing the commoner functional groups. The last chapter in the book reviews the various suggestions offered for the mechanism of reduction by the hydride.

Considering the tremendous literature of the subject, the authors have done very well indeed to produce, as they have, a small, readable volume which gives the general chemistry, shows up the important features, and gives no fewer than 1,732 references to the literature. The book is written by two men who have themselves experimented with lithium aluminium hydride and therefore are capable of appreciating its amazing versatility as a reagent. The chemistry is well described, with clear reaction formulæ.

E. E. TURNER

PERMAFROST RESEARCH IN NORTHERN CANADA

By ROBERT F. LEGGET
Director of the Division of Building Research, National Research Council, Canada

A NEW Northern Research Station for Permafrost Research was recently dedicated at Norman Wells, Northwest Territories, by Dr. E. W. R. Steacie, president of the National Research Council of Canada. The opening of this far northern laboratory coincided with a visit of members of the National Research Council to the northwest of Canada. This visit and the establishment of the station at Norman Wells are significant indications of the steady awakening of Canada's northland.

The tour of the members of the National Research Council followed the regular summer meeting of the Council, which was held in Saskatoon instead of Ottawa as is the usual practice. Two years ago the Council had its first special summer meeting in Newfoundland, visiting this newest of the ten provinces of Canada in order to demonstrate the interest of the Council in the scientific and technical problems of this island province. The visit to northwestern Canada was arranged in view of the success of the visit to Newfoundland, and in order that the members of the Council might gain personal acquaintance with the great Mackenzie River valley, seeing also something of current developments on the arctic coast.

The party numbered about thirty. Most of the members made the tour by a specially chartered aeroplane; others were able to make most of the journey using regular commercial airline services. The party proceeded from Saskatoon to Beaverlodge on the northern shore of Lake Athabasca, where they inspected one of the major uranium mines of Canada. They then proceeded to Yellowknife, the mining centre of the Northwest Territories, and there inspected an operating gold mine. The next part of the journey was to Norman Wells, which the party used as a centre for special flights to the arctic coast. One of these was to Tuktoyaktuk, where the members were able to visit an Eskimo village and one of the DEW-line radar early-warning stations now under construction. No greater contrast between new developments in northern Canada and its traditional life could be imagined. The other special flight was to the existing town of Aklavik, located in the middle of the great delta of the Mackenzie River, at the meeting point of Indians from the south and Eskimos from the north. This principal settlement of the arctic coast is shortly to be moved to a new site on the east rim of the delta. The party was able to visit the new site and to see the start of construction for the new Aklavik.

After inspecting the facilities of Imperial Oil, Ltd., at Norman Wells, and the new National Research Council research establishment, the party flew up the Mackenzie valley to Fort Simpson, where a special Experimental Farm of the federal Department of Agriculture now has more than 50 acres under active and successful cultivation. Flight was then made over the mountains to Whitehorse, capital of the Yukon Territory, where local engineering developments were inspected prior to the return of the party to Edmonton. During this journey of more than 8,000 miles, the Council held two special dinner meetings, at Yellowknife and Whitehorse, where they met leading local residents and had an opportunity of bringing research to the attention of those concerned with the development of these northern communities.

It was during the visit to Norman Wells that Dr. Steacie, in the presence of most of the members of the National Research Council and of a large proportion of the local population, officially opened the two new prefabricated buildings of the Northern Research Station of the Council's Division of Building Research. The buildings are of simple wooden construction, designed and constructed for service in the rigorous climate of Norman Wells. They are so arranged that they can be moved in the future, if it should be found eventually that the new Aklavik will be a more suitable location for the station. The residence measures 24 ft. by 48 ft. and can accommodate five or six research workers. The other building, 24 ft. by 72 ft., is a fully equipped soil mechanics laboratory with an associated workshop and garage for the special drilling and sampling equipment needed for permafrost investigation.

Norman Wells was selected as a site for this research establishment after careful survey of all possible sites in the northwest of Canada, most of which lie along the banks of the Mackenzie River. It is the present terminus for the wheel-equipped aircraft used on the regular commercial route of Canadian Pacific Air Lines; it is thus conveniently located for transportation. It is the site of a small oil field and oil refinery of Imperial Oil, Ltd., so that this Company's shop and service facilities are available. These have been most generously placed at the disposal of the National Research Council staff at the station at Norman Wells. The building programme of Imperial Oil has itself provided most useful information and experience with the special problems created by construction on permafrost.

More than one-third of the land area of Canada is underlain by perennially frozen ground. In all this northern area, the temperature of the ground, below the depth to which daily temperature-fluctuations are experienced, is 32° F. or colder. The depth at which freezing temperatures occur varies from a relatively few feet near the southern boundary to well over one thousand feet in the Arctic Archipelago. When the ground consists of solid rock, or of dry sand and gravel, the sub-freezing temperatures are of scientific interest but of little practical consequence. When, however, the frozen ground consists of water-bearing soil, and especially if the soil is silt (as is usually the case, in view of the recent glacial history of most of northern Canada), the practical consequences can be serious indeed if the natural temperature regime of the ground is disturbed.

It is to describe such conditions of terrain that the word 'permafrost' has come into general and popular use within the past two decades. Philologically, objection can be raised to the name[1], particularly since its generally accepted use really implies its application to all perennially frozen ground

and not just to frozen silt; but it appears to be too late now to attempt to change this popular usage.

In natural circumstances, perennially frozen silt and other water-bearing soils will thaw out to shallow depths as the summer season progresses. Depths of thaw up to two, and sometimes even three, feet have been observed beneath the almost invariable surface vegetal cover, to which another popular name, 'muskeg', is usually applied. Re-freezing takes place rapidly following the end of summer heat. The water thus released beneath the muskeg cover of so much of northern Canada is what makes summer overland travel so difficult and hazardous in this region. The regular thawing and re-freezing is associated with the polygonal surface patterns frequently found in perennially frozen areas.

When it is necessary to carry out in the north engineering operations such as the building of roads and airports, and the erection of all but the smallest permanent structures, troubles may quickly develop when the ground is disturbed if it is found that the site is underlain by frozen silt. Once the natural vegetal cover is removed, more extensive thawing than usual will occur. Since the frozen silt will usually prove to be saturated or even super-saturated when thawed, and as it is usually slow draining, road and airport construction in permafrost can be extremely troublesome. Correspondingly, the heat lost from buildings can cause permanent and serious changes to the natural soil and ground temperature regimes, thus necessitating unusual foundation designs.

The first objective of the new research station at Norman Wells is to provide the necessary laboratory facilities and field-investigation equipment for the study of such practical building problems of the Canadian north, problems which have been multiplied in recent years as the development of the north has accelerated and as the standards used for northern buildings have been improved. Accurate study of soil conditions at proposed building sites is a first requirement. This has led to the development of special test-drilling techniques, such that cores of frozen soil can be obtained for study and analysis, and of somewhat unusual field-photographic procedure for the investigation of the exact ice formation in samples without recourse to elaborate (and costly) refrigerated equipment for sample storage and transport.

The new research station at Norman Wells will serve as a centre for this specialized field-research, the terrain near the station providing a most suitable area for test installations and investigations. The laboratory is fully equipped for the detailed study of the physical and mechanical properties of the soil content of samples of permafrost. Laboratory and workshop facilities will be used for the preparation of the extensive instrumentation required for the investigation of the ground-temperature regime in undisturbed areas and at the sites of engineering works.

The study of such practical problems is but one part of the assignment of this Northern Research Station, the other being a more general scientific investigation of permafrost as a natural phenomenon. Plans have been developed for permanent installations which will eventually demonstrate whether the permafrost of Canada is a static condition or one which is changing with time. The staff assigned to this work have, however, been diverted almost completely since the start of their work in 1952 (in temporary quarters) to the necessary study of permafrost at the existing town of Aklavik and to the extensive survey investigations carried out before the new town site was discovered and finally selected. Studies are continuing at both the new and the old sites and should eventually yield results of unusual significance.

Among other scientific projects in view is the drilling of a deep hole for the study of deep-ground temperatures. This will be complementary to those already in use at Point Barrow, Alaska, and Resolute Bay, Northwest Territories. Investigation of temperatures in *pingoes* is already under way and other studies of the variations of ground temperature at shallow depths. With the new laboratory facilities now available, and the new town site for Aklavik well started towards its full development, it is hoped that the long-planned research into the more scientific problems of permafrost in northern Canada can soon be prosecuted as planned[2]. The Norman Wells station will be available for use by guest workers with the National Research Council. It is a satisfaction to be able to conclude this note by reference to the first such guest workers, two British geologists, who are visiting northern Canada on a special mission.

[1] Bryan, Kirk, *Amer. J. Sci.*, **234**, 622 (1948).
[2] Legget, R. F., "Permafrost Research", *Arctic*, **7**, Nos. 3 and 4, 153 (1954).

U.K. ATOMIC ENERGY AUTHORITY

SECOND ANNUAL REPORT

THE second annual report of the United Kingdom Atomic Energy Authority*, covering the year ended March 31, 1956, follows the pattern of the first annual report. The dominant feature of the year has been the great increase of interest and activity in the development of nuclear energy as a source of power for peaceful purposes, which has coincided with a considerable advance in the removal of security restrictions on information in this field. These questions and also the implications of the staff position in relation to the man-power situation in Britain and in regard to technological education are discussed elsewhere. For the rest, it may be said that generally the report presents a concise and readable picture of technical developments during the year, many of which have already been made known in the Press. The report, however, puts them in their proper perspective. Moreover, the Authority recognizes so clearly the importance of a clear public understanding of exactly what it is doing that it has supplemented the report with an admirable illustrated summary*, which should bring home to the

* United Kingdom Atomic Energy Authority. Second Annual Report for the period 1st April 1955–31st March 1956. Pp. iv+46. (London: H.M. Stationery Office, 1956.) 2s. 6d. net.

* Atom 1956: An Illustrated Summary of the Second Annual Report of the United Kingdom Atomic Energy Authority. Pp. 24. (London: H.M. Stationery Office, 1956.) 1s. 6d. net.

ordinary citizen the nature of the problems with which the Authority is faced and the magnitude of its operations.

During the past year, nuclear power has become for most countries a matter not of conjecture but of dates, and comparative costs and the increase in activity of industry in the United Kingdom and of governments and industry overseas constituted a new feature of national and international affairs. Nevertheless, there has been no reduction in the Authority's activities on the defence side. The nuclear weapons programme, and particularly the development of thermonuclear weapons, continued to have high priority, and the rate of increase of staff was higher in the Weapons Group than elsewhere in the Authority, the total staff of which increased from 19,895 in April 1955 to 23,973 in 1956. During the year, the Authority decided that the work of the Weapons Group, under the direction of Sir William Penney, should include responsibility for research into, and development of, nuclear reactors for military application.

As a measure of overseas interest in the British nuclear energy programme and of the Authority's overseas contacts, the report refers to visits to the Authority's establishments during the year by representatives of thirty-six countries. The new full-time member of the Authority appointed in October, Mr. W. Strath, is largely concerned with overseas atomic energy organizations, as well as with raw material procurement and the Authority's relations with industry. Construction of new capital facilities continued at almost all the Authority's establishments during the year; but Harwell has now almost reached the maximum size compatible with efficient management and the avoidance of unreasonable pressure on the facilities of the surrounding countryside. Research and development, however, continue to demand more scientific staff and working space, and the Authority is examining new sites with the view of setting up a further major research establishment to which new research and development projects could be directed. Additional net expenditure of £3,550,000 was required for 1955–56, beyond the estimate of £50,562,000 presented to Parliament in February 1955, mainly to implement the Government's decisions to develop thermonuclear weapons, to carry out a nuclear power programme and to increase the output of plutonium, for which purpose three new units of the Calder Hall type are to be built, one at Calder Hill and the others at Chapel Cross, near Annan. The net estimate for 1956–57 presented to Parliament in February was for £68,242,000.

The Authority has also faced a major task in establishing commercial accounting systems throughout the organization. A foreword to the balance sheet appended to the report points out that the whole of the cost of operation of factories by the Industrial Group is regarded as recoverable in the price of its products, and expenditure on research and design in aid of future projects is carried forward for later amortization and recovery. The whole of the cost of operation of the Research Group, less proceeds of sales of radioactive substances, electronic equipment and other income, is regarded as the cost of fundamental research in the nuclear energy field to be borne by the Exchequer. Under contract from the Ministry of Supply, the Weapons Group undertakes the production of components for weapons and research work in connexion with weapons; and the cost of operation of this Group, including that of other advanced research, less the amounts chargeable to the Ministry of Supply for production and research, and other income, is regarded as a charge to be borne by the Exchequer.

The spate of new discoveries, most of them on the North American continent, has removed the danger of a world-wide shortage of uranium. For its current uranium imports the Authority continued to depend on contracts placed by the Combined Development Agency on behalf of the Authority and the United States Atomic Energy Commission, and has received the first shipment of concentrates from the mines at Rum Jungle and at Radium Hill, Australia. An extension of the contract for the supply of uranium ore and concentrates from the Shinkolobwe mine is being negotiated and the output of uranium concentrates from the Transvaal and Orange Free State mines continues to grow. During the year, the first contracts were signed for delivery of uranium direct to the United Kingdom, and steps were taken to foster an interest in uranium prospecting in the Central African Federation. Technical developments in regard to materials noted in the report include, among chemical methods of extracting uranium, the publication of an account of the ion exchange process, in which work the Radiochemical Group of the Chemical Research Laboratory (Department of Scientific and Industrial Research) co-operated, arrangements to create additional capacity for production of graphite in the United Kingdom and investigation of the production of special grades of graphite for future reactors, the change from calcium to magnesium in the reduction of uranium tetrafluoride to metallic uranium and the continued manufacture of fuel elements to meet the needs of Bepo and of the Windscale piles. Further sections of the gaseous diffusion plant at Capenhurst have been commissioned and the output of the plutonium-producing piles at Windscale has been further increased. Steady progress has been made in the development of maintenance techniques for use inside the pile shield, thereby easing the severe limitation on design and choice of equipment. Chemical processes developed at Harwell for the complete separation of the fissile uranium-233, fertile thorium and the radioactive fission products from neutron-irradiated thorium have been operated on a small pilot-plant scale.

The report gives some particulars of progress with the prototype nuclear power station at Calder Hall and the fast breeder reactor at Dounreay, and satisfactory progress has been made with the Harwell swimming-pool reactor (named Lido) for research and development related to the problem of shielding. The heavy-water-cooled and moderated thermal reactor, Dido, was expected to come into operation towards the end of July 1956 and is to be used for a limited amount of engineering loop work, and work has been commenced on the design and manufacture of special experimental equipment and devices for the production of isotopes and on the design and construction of the first of the engineering loops to be installed in the heavy-water high-flux reactor, Pluto, to test the technology of advanced reactor systems. While the first nuclear power stations will be built away from heavily built-up areas, the Authority has set up a panel of its own specialists with representatives of the electricity undertakings to consider the problems of the siting of reactors.

The Authority's reactor research programme is further described in a separate chapter of the report. A substantial amount of work is still being done on the graphite-moderated gas-cooled reactors being designed by industry for the Central Electricity Authority, and several loops have been built to study the corrosion of carbon steels and stainless steels under the conditions likely to be experienced in pressurized-water reactors, while the use of organic liquids such as diphenyl and terphenyl as alternative to the water moderator and coolant is being investigated. Reactor physics and metallurgical and engineering investigations are being carried out on the alternative reactor using graphite as a moderator and liquid sodium as coolant. In addition to the organic system just mentioned, four other reactor systems are being examined for attaining a much higher fuel-utilization by breeding: the fast reactor system; the homogeneous aqueous reactor system, which attempts to achieve breeding in the uranium-233–thorium system, with very low fuel costs; the liquid-metal fuelled reactor system, using a graphite moderator and enriched uranium dissolved in a liquid metal; and the high-temperature gas-cooled reactor system. Treatment of irradiated uranium by solution in acid and extraction with organic solvents continued to be a successful method for separating plutonium and recovering uranium for re-use on the industrial scale, and pilot-plant experience has been gained of the process for the extraction of uranium-233 from irradiated thorium. Work on the production of a controlled thermonuclear reactor, in which the two main problems to be solved are to bring a mixture of the light elements to a temperature in the region of 100 million deg. C., and to maintain this long enough for the energy released in nuclear fusion to exceed that required to heat the fuel, is still in the laboratory stage.

Besides occupational health problems, the Authority pays much attention to those of waste disposal, including measures to ensure full protection of the public from possible exposure to radioactive materials. Sales of radioactive isotopes steadily increased, totalling £483,000, rather more than half of which was for export; the number of consignments was 22,378 compared with 18,835 in 1954–55. The potential uses of radioactive by-products in industry is being actively explored by the Technological Irradiation Group of the Isotope Division, working in close co-operation with industry, and the biological application of irradiation in sterilization and mutation is being actively studied. Antibiotics which are normally destroyed by heat sterilization can be completely freed from bacteriological contamination by simple irradiation. Some 15,000 curies of cobalt-60 have been made and loaded into machines for cancer teletherapy and for industrial irradiation. Among new applications of radioactive isotopes may be mentioned the use of ammonium phosphate containing radioactive phosphorus to investigate the pollution of beaches by sewage; and the use of weak radioactive solutions to detect leaks in water mains and oil pipe-lines up to twenty miles in length.

During the year, 167 students attended the normal four-week course in the Isotope School and 104 attended special courses. The Reactor School at Harwell throughout the year gave training to staff from industrial firms on the construction and operation of nuclear reactors; and while the export of nuclear reactors will be the responsibility of industry, it will fall to the Authority to provide the necessary fuel elements. The Authority expects to be able to provide natural uranium fuel elements to match whatever volume of export business is secured in the foreseeable future. Up to the present, twenty-two licences have been granted to United Kingdom firms to use inventions owned by the Authority, three to United States firms, one to a firm in West Germany and one to a firm in France.

EFFECTS OF ATMOSPHERIC POLLUTION IN FORESTRY

DURING the recent Sheffield meeting of the British Association, the morning session on September 4 of Section K* (Forestry) was devoted to four papers on "Forestry in Industrial Areas, with special reference to Smoke Pollution".

Mr. E. M. Conder (Forestry Commission), in a contribution on "Some Problems of Private Forestry in the Industrial Areas", pointed out that air pollution is not the sole cause of the lack of satisfactory coniferous tree growth in the immediate vicinity of large industrial cities, for fire and theft are also responsible in some measure. From experience in Lancashire, the Black Country, the Nottinghamshire coalfield, and parts of South Yorkshire, he considers sycamore, beech, elm and poplar the most successful timber-producing hardwood species, with other generally resistant but subsidiary species as follow: horse chestnut, birch, holly, rowan, whitebeam, common alder. Only the black pines (with particular emphasis on the Austrian variety) and, in certain circumstances, Japanese larch, can be recommended among the conifers. Besides these there are few species to suggest, apart from monkey puzzle, yew and perhaps the cedars and Lawson's cypress. Trials with *Pinus contorta* are as yet too young to provide conclusive material and, while Scots pine may be vigorous initially, subsequent development is poor. Mr. Conder suggested that, in high valleys and on hill slopes, trapping of injurious gases by prevalent low cloud may explain the serious effects at these sites. It was emphasized that in surveying pollution effects, attention must always be paid to the fertility of the soil and, among climatic factors, to the influences, in particular, of elevation and exposure.

Atmospheric pollution effects in Yorkshire were discussed by Mr. A. J. Grayson (Forestry Commission), who suggested that though pollution as generally viewed is deleterious, it may imply useful additions to the existing natural 'chemical climate' before the concentration of individual pollutants or combinations gives rise to injury. Historical evidence shows something of the extent to which changes of species in plantations are to be ascribed to the effect of coal-smoke pollution during the past century. However, the elucidation of the factors bringing about deterioration and even death is difficult since the production of smoke is matched by an increased need for timber, leading to preferential cutting, as

well as, more recently, preferential selection of species. A physical basis of measurement of some of the common pollutants is desirable only in so far as biological assays are hedged with difficulties as to interpretation.

The stimulus for the investigation of country levels of pollution is provided by the need to afforest difficult sites on both sides of the Pennines on inhospitable soils exposed to a dull and harsh climate, where the choice of economic species is in any case restricted. The disentangling of pollution/exposure and pollution/fertility interactions (if either be possible) is the prime need. In the first place, Forestry Commission research has begun with the assessment of sulphur dioxide by the lead peroxide method. Similar levels indicated by this technique give no assurance that solid deposits will follow similar trends, and the variation in the ratio of water-soluble to insoluble matter collected in deposit gauges indicates the wide range of types of emission, as well as of the history of that emission. The disadvantages of the lead peroxide method may be in its manner of integration, so that in the absence of other observations a particularly highly concentrated visitation at a time of high plant susceptibility may pass undetected.

More fundamental is the question of the effect of prevalent high wind velocities on the rate of formation of sulphate. Two examples, one of moor top as opposed to valley stations in open country, the other of a gauge sheltered by a wood and contrasted with gauges on either side of the wood, suggest discrepancies which may not in fact reflect true differences of sulphur dioxide concentration. Fumigation experiments with sulphur dioxide, often of short duration, have usually been carried out in the past with concentrations of 1–100 times those averaged over a month occurring naturally, though occasionally concentrations in Nature may increase to the higher levels used in fumigation experiments. Mr. Grayson suggested that apart from species (and possibly strain), concentration, and period of fumigation, different ages of plant or plant organs should be treated in fumigation experiments, since field-observation suggests that atmospheric pollution effects are often most noticeable in trees after the grand period of height growth is finished.

A paper prepared by Dr. G. Scurfield (at present with the Commonwealth Scientific and Industrial Research Organization, Canberra) was read by the chairman, Mr. M. V. Laurie. Dr. Scurfield began by asking three questions: (i) Is there unequivocal proof that pollution effects are operating to reduce timber yield on certain sites? (ii) Given such sites, can we designate the pollutants causing the reduction in yield and, if so, can we define an upper permissible limit of concentration for the pollutants concerned? (iii) Given such pollutants, in what ways do they interfere with the developmental processes of the tree so as to cause a reduction in yield?

Observations of decline in vigour of tree growth from cities tend to support the contention that the effects of general pollution are cumulative and need not be accompanied by the production of visible leaf lesions. Many such observations are concerned with effects produced by 'general' atmospheric pollution after the contaminants have undergone considerable dilution and probably interaction. The effects produced by temporary and usually local increases are more certain, and have in a number of cases been checked by means of fumigation experiments. Field-symptoms have been also duplicated in experiments with hydrogen fluoride where this agent has been suspected.

The different levels of pollution which evergreen and deciduous species have to endure are brought out on the typical annual sine curve of sulphur dioxide and smoke (which is of great chemical complexity, but which contains a number of other contaminants) in the vicinity of urban areas. The cumulative effect of a number of pollution cycles is probably to reduce growth indirectly by accelerating leaf abscission. Experiments to determine tolerances in known environmental conditions might be carried out on the following bases: (i) using transplants in the same soil but different pollution regimes, alongside meteorological stations so that any microclimatic differences between sites could be assessed; indicator species (for which damage symptoms for specific pollutants have already been assessed) might also be included; (ii) using growth chambers through which 'screened' air could be passed, so that specific agents responsible for reduction in growth would eventually be determined. Lastly, by using 'phytotron' techniques, tolerances to combinations of the variables might be determined. Such techniques could also be used to assess the indirect effect on soil fertility.

In answer to the second question posed, Dr. Scurfield emphasized how necessary it is to avoid the tendency to regard sulphur dioxide as the sole gaseous pollutant. In addition to thirty gases listed by the Alkali, etc., Works Registration Act, 1906, recent analyses have shown hitherto unsuspected contaminants. Further, there are the chemical or physical processes occurring after emission; for example, the reaction products of ozone and certain hydrocarbons. Radioactive isotopes, also, should not be ignored altogether. The permissible concentrations allowed to pass to the air are, so far as sylviculture is concerned, largely arbitrary. Upper limits of tolerance will wait on results through the species' ontogeny and under known conditions. When these are known, concentration limits must be reassessed in relation to topography and atmospheric conditions. Where inversions are liable to occur, for example, the ideal solution would be the regulation of rates of emission in accordance with the diffusing properties of the atmosphere at the time. Thus thorough evaluation of sites from a meteorological and atmospheric pollution point of view should preferably be undertaken before planting.

Thirdly, with regard to the physiological processes concerned, it may be said that the most prominent effect of 'general pollution' is to cause premature leaf abscission. Organic sulphur compounds may play some part in these phenomena. Though abscission may not always be due to the same agent, some mitigation might be obtained by treatment with compounds so affecting auxin activity as to retard abscission. Effective elimination of harmful sources will only be undertaken, said Dr. Scurfield, if we emphasize the effects and if we can point to the agents responsible.

Finally, Dr. P. F. Wareing (University of Manchester), who explained that he was in part deputizing for Dr. J. K. A. Bleasdale, whose thesis on the decline of certain leys in the hill pastures of East Lancashire had shown valuable results, and for Dr. Scurfield, who had also worked at Manchester, proceeded to amplify and clarify many of the points mentioned in previous papers. In discussing what is the important

pollution factor, he pointed out that while good grounds exist for considering sulphur dioxide the main injurious agent, we have not yet determined that some of the accompanying products of coal combustion may not bring about injuries, such as have been described for pollutants resulting from the combustion of petroleum in Los Angeles. The work on fumigation with sulphur dioxide in greenhouse experiments involves only relatively short-term experiments at high concentrations. This provides no real simulation of the processes occurring in Nature. Dr. Wareing also stressed the fact that the most susceptible parts of plants are the leaves, so that evergreens, which retain their leaves during the winter when pollution is usually at the highest levels, are generally less resistant than deciduous species. Nevertheless, other factors must be of importance, since there are marked differences as between different species both among evergreen and deciduous plants.

Further elucidation was provided by Dr. Wareing in the discussion which followed. Mr. M. V. Edwards (Forestry Commission) brought matters down to earth in referring to the effects visible on some of the high upland plantations. Here similar symptoms of damage are noticeable on young trees where they are seriously exposed to 'clean' winds and those exposed on the South Pennines to smoke-laden winds. The design of experiments required to isolate the factors of pollution and exposure meets with very serious difficulties. The provision of shelter, for example, automatically means the bringing into existence of a different pollution regime. Mr. A. Bleasdale (Meteorological Office) said that if foresters working in this field need help from meteorologists, then they should be as detailed as possible in stating their requirements so that records could be used most effectively.

Both this discussion and the papers point to the great need for study of the cumulative effects in sylviculture of pollution, in addition to the determination of the toxic concentrations of individual contaminants and combinations of pollutants under known conditions.

A. J. GRAYSON

RESPIRATORY PIGMENTS

IN opening a discussion on "Respiratory Pigments" arranged by Sections D (Zoology), H (Anthropology) and I (Physiology) at the Sheffield meeting of the British Association, Prof. F. J. W. Roughton reminded his audience that eight years had passed since the Barcroft Memorial Conference on hæmoglobin had met at Cambridge, and said that they had been years of rapid progress, some of it stimulated by that Conference. In the discussion three groups interested in hæmoglobin were all represented: they were physiologists, who are concerned with its role in promoting gas exchanges in the animal body, biochemists interested in the mechanism and physical chemistry of the gas reactions, and biophysicists who find it an easily available and readily crystallized material already carefully studied and characterized physiologically.

The first paper, by Profs. Q. H. Gibson and F. J. W. Roughton, was concerned with the thoroughgoing application of Adair's intermediate-compound hypothesis to the equilibria and kinetics of the reactions of hæmoglobin with gases. Adair's original paper, published thirty-one years ago, suggested that combination of each hæmoglobin molecule with four molecules of gas takes place in four distinct stages, one gas molecule combining at a time to yield separate molecular species containing one, two, three or four gas molecules.

The general acceptance of Adair's hypothesis has been delayed by the failure of attempts to demonstrate the intermediate compounds spectroscopically, and because the equation giving the relation between oxygen tension and percentage saturation arising from the intermediate-compound hypothesis contains four constants—enough to allow any ordinary experimental equilibrium curve to be fitted within 0·5–1 per cent saturation by several sets of constants with widely differing values.

In recent years, Roughton and his co-workers at Cambridge have overcome the second difficulty by refining the methods used for determining the dissociation curve and extending them to the ranges 0–1 per cent and 98–100 per cent saturation, so that only one set of constants can be found to fit the experimental results. This work has shown that, for sheep hæmoglobin, there is a great increase in affinity for oxygen after three molecules have combined, the affinity for the fourth molecule being, at *p*H 9·1, 280 times greater than that for the first.

The kinetic work described in the same paper is an example of co-operative research carried on by several groups of workers. The problem was to determine numerical values of the four combination velocity constants for the reaction of reduced hæmoglobin with carbon monoxide. The experimental material, records of the change in concentration of reduced hæmoglobin with time, was obtained by the stopped-flow photo-electronic method, in Sheffield. The percentage saturation was found to within 0·5 per cent during the period from 5 to 100 msec. after bringing the reactants together, using a photomultiplier and cathode-ray oscillograph to follow the reaction. The results were then compared, by Dr. H. E. Daniels, of the Cambridge Statistical Laboratory, with solutions of the differential equations describing the reaction. These solutions were computed by the EDSAC electronic machine in the Cambridge Mathematical Laboratory. In this way the values of the individual velocity constants for the combination of successive carbon monoxide molecules were found, together with their standard errors. Here again, with sheep hæmoglobin at *p*H 9·1, it was found that a great increase in combination velocity took place after three molecules of carbon monoxide had combined, the fourth molecule combining some sixty to eighty times faster than the first.

Although the new results have allowed the unequivocal application of the intermediate-compound hypothesis to one kinetic case, much remains to be done, especially to extend the analysis to the physiologically interesting case of combination with oxygen, though the formidable difficulties of reckoning with eight independent kinetic constants may well delay a solution for some time.

Dr. V. M. Ingram followed with an account of recent progress in research on the structure of hæmo-

globin by X-ray methods. The present position is that while projections of the molecule are available which tell us how much material lies in the line of sight in a given direction, more detailed information can only be obtained by making projections of thin slices of the molecule.

Certain specific groups have, however, been located by labelling them with heavy-metal atoms which show up on X-ray diffraction analysis. It has been found, in this way, that the —SH groups of horse hæmoglobin are arranged in close pairs. As Riggs in the United States has recently shown that the —SH and hæm groups have a close functional relationship, it is not impossible that they may be close to one another in the molecule.

Very recently a striking new advance has been made in the study of sickle-cell anæmia. In this condition the hæmoglobin differs from normal in the number of its —SH groups, its solubility and in the remarkable property of forming a gel on reduction. Dr. Ingram has now found, using a combination of paper chromatography and paper electrophoresis, that a peptide appears regularly among the products of tryptic hydrolysis of sickle-cell hæmoglobin which is not present in similar hydrolysates prepared from normal human hæmoglobin. As sickle-cell anæmia is the result of change in a single gene and is inherited in a strict Mendelian way, the possibilities of an increase in our understanding of the relation between genes and proteins synthesis are obvious.

After an interval, Prof. Q. H. Gibson described some applications of flash photolysis to the study of hæmoglobin kinetics. The observations, so far, have been made with a simple apparatus in which the solution to be examined is exposed to the photolysis flash in an integrating sphere and the changes in light absorption are recorded by means of a continuous light source, photocell, and cathode-ray oscillograph. The systems studied are arranged so that at equilibrium the chief compound present is carboxyhæmoglobin, which, as is well known, is sensitive to light. On firing the photolysis flash, this carboxyhæmoglobin is caused to dissociate, setting free reduced hæmoglobin. After the flash ends, the recombination of the reduced hæmoglobin with carbon monoxide or with other ligands forming compounds less stable than carboxyhæmoglobin can be studied.

One application of the method has led to a dramatic confirmation of the difference in kinetic properties between the different intermediate compounds of carbon monoxide with hæmoglobin. By reducing the power of the photolysis flash, partially saturated intermediates can be formed in the solution in calculable quantities. It is found that when large proportions of the intermediate $Hb_4(CO)_3$ are formed, the recombination reaction involving the addition of the fourth and last molecule of carbon monoxide to combine takes place up to sixty times faster than when only fully reduced hæmoglobin is present. It is satisfactory that such good agreement can be reported between the widely different approaches to the kinetic problem described at this meeting, since this rapid reaction was predicted from measurements of the upper end of the dissociation curve and the velocity of dissociation of the first molecule of carbon monoxide from fully saturated hæmoglobin.

Another application reported was to the study of hæmoglobins from invertebrates. Here the advantage of the flash method is its economy in material. This economy must now be approaching its highest possible degree, since the same material can be used repeatedly in duplicate experiments or in runs under altered conditions. It is interesting to reflect that in the thirty-three years since Hartridge and Roughton made the first measurements of the reaction velocity of hæmoglobin with gases, the pigment requirements have been reduced some 100,000 times. It is now readily possible to examine the hæmoglobin from a single specimen of *Arenicola*, say, or of *Chironomus*, but it would seem that several specimens of *Daphnia* would still be needed.

In the final paper of the meeting, Prof. F. J. W. Roughton described the application of some of the kinetic work to the problems of passage of gases from the alveoli into combination with the hæmoglobin. This process, at first sight deceptively simple, must in fact be split up into a number of component steps, each of which plays its part in determining the rate of the overall process. The gas molecules concerned must first diffuse through the alveolar membrane, then through the plasma to the erythrocyte, through the cell membrane of the latter, and finally through the interior of the cell until they meet a hæmoglobin molecule with a vacant gas-binding group.

It has now been possible to evaluate the importance of each of these factors in contributing to the final physiological result. It has been found that the resistance of the alveolar membrane and the resistance in the erythrocyte contribute about equally to the difficulty met with in the uptake of carbon monoxide or oxygen from the alveoli into combination with hæmoglobin. In the erythrocyte, the chemical combination reactions with oxygen and nitric oxide are so rapid that the actual rate of gas uptake is determined primarily by the rate of diffusion through the red-cell membrane and the interior of the cell modified only slightly by the rate of the chemical reaction. With the slower reaction of the displacement of oxygen by carbon monoxide, the rate of the chemical reaction already plays an important part; and when we come to consider the dissociation of carboxyhæmoglobin the picture is reversed, the chief rate-limiting factor now being the chemical reaction, which is slow as compared with the rates of diffusion in the blood and across the membranes.

The new quantitative descriptions of the exchange processes in the blood and lungs have been applied to determine anew the diffusing capacity of the lung membranes and the volume of blood in the lung capillaries. The greater certainty about these processes should lead to advances in fields as diverse as clinical medicine, long-distance running, and in knowledge of how life is carried on at high altitudes.

OBITUARIES

Prof. Carl Neuberg

On May 30 Prof. Carl Neuberg died in New York at the age of seventy-nine. With Neuberg's death ended a succession of brilliant German organic chemists, born and trained in the last century and devoting their life-work mainly to the application of newly developed chemical methods to the study of the components of living matter, their composition, structure and metabolic changes; among them were Friedrich Wöhler, Justus v. Liebig, Felix Hoppe-Seyler, Adolf v. Bayer, Albrecht Kossel, Emil Fischer, Franz Hofmeister and Richard Willstätter.

Equipped with a broad knowledge of, and deep insight into, organic chemistry, possessed by a passionate interest in the material changes of living matter and endowed with a rare skill for devising methods suitable to a direct approach to the problem, Neuberg was one of the founders of modern biochemistry.

Born on July 29, 1877, at Hannover (Germany), he received his scientific training in the Universities of Berlin and Würzburg. In 1898 he joined E. Salkowski in the Chemical Division of the Pathological Department of the University of Berlin; in 1909 he was appointed head of the Chemical Unit of the Department of Animal Physiology at the Agricultural College, Berlin, and in 1913 he became assistant director of the Kaiser Wilhelm Institute for Experimental Therapy under August v. Wassermann, whom he succeeded in 1925. The Institute became one of the foremost centres of biochemical research. Although Neuberg had given signal service to his native country both in peace and in the First World War, he was forced by the Hitler regime to leave it in 1939. He found refuge in the United States, where he was at first research professor at the College of Arts and Sciences of New York University and then professor at the Brooklyn Polytechnic Institute and at the New York Medical College.

Neuberg's main contribution to science was the elucidation of the principal mechanism underlying alcoholic fermentation of sugar by yeast. This process, though the subject of violent controversy between the most illustrious chemists of the last century, remained an unsolved mystery until Harden and Young in London and the Neuberg school at Berlin entered the field. The first step in unravelling the integrated series of reactions by which the carbon chain of the sugar molecule is disrupted was the demonstration that pyruvic acid is readily and quantitatively transformed to carbon dioxide and acetaldehyde by a yeast enzyme named carboxylase. The next step was the trapping by sodium sulphite of the intermediary acetaldehyde in the course of glucose fermentation. The hydrogen becoming available through the formation of the carboxyl group of pyruvic acid, but deprived of its physiological acceptor acetaldehyde, was traced in glycerol, produced in stoichiometric quantity to the trapped acetaldehyde. The interpretation of these findings was given by Neuberg in a fermentation scheme the main features of which were: (1) dehydration and de-aldolization of one mole D-glucose to two moles of a 3-C-aldehyde assumed to be methylglyoxal, (2) oxidation of the ketoaldehyde to pyruvic acid, and (3) reduction of the decarboxylated pyruvic acid to alcohol.

The concept of alcoholic fermentation as the balanced sequence of an energy-yielding dehydrogenase reaction and a reaction in which a hydrogen acceptor derived from the first reaction combines with the hydrogen atoms released proved to be one of the most fruitful theories in the realm of fermentation and respiration. Neuberg demonstrated clearly that the end-products of sugar fermentation by yeast vary with the nature of the hydrogen-accepting system available. The ideal fermentation equation of Gay–Lussac is never verified because yeast on metabolizing sugar forms a variety of competing hydrogen-acceptors, their quality and quantity depending on the conditions imposed. Neuberg realized the key position of pyruvic acid in the metabolism of fungi and bacteria and ascribed the great diversity of products formed in the various types of fermentation mainly to the formation of a wide range of hydrogen-acceptors from pyruvic acid. It may be said with confidence that the production of pyruvic acid, isolated in high yield from fermenting sugar solutions by Neuberg in 1929, is the central stage of a carbohydrate degradation pathway very common in living cells; this central stage is preceded by phosphorylating and desmolatic steps and followed in respiration by the Krebs cycle, in fermentation (glycolysis) by reduction of pyruvic acid or a derivative thereof.

In addition to carboxylase, Neuberg discovered the enzymes β-glucuronidase, methylglyoxalase, phenolsulphatase, chondrosulphatase, polyphosphatase and metaphosphatase. His wide interest and experimental skill are documented by many other notable achievements. Among them are studies on the structures of raffinose, inositol and phytin, first non-enzymatic preparation of phosphorylated sugars and amino-acids, discovery of fructose-6-phosphate (Neuberg ester), first observation of the carboligatic reaction and synthesis of the various phosphoglyceric acids.

Neuberg's work has done much to shape present trends in biochemistry and his contributions to knowledge will long be remembered. In 1906 he founded the *Biochemische Zeitschrift* and edited no less than 278 volumes in the next thirty years. Among the many honours bestowed upon him were the Emil Fischer, Delbrück, Pasteur, Berzelius, Scheele and Leblanc Medals, and the Carl Neuberg Medal established by the American Society of European Chemists and Pharmacists in 1950. He received several honorary degrees, and was a member of many scientific academies. Of Neuberg may be said what he himself said at the funeral of his predecessor A. v. Wassermann in 1925: "He belonged to the small band of scientists who visibly moved the hand of the clock recording the advancement of science".

ALFRED GOTTSCHALK

Dr. Gunnar Dahlberg

DR. GUNNAR DAHLBERG, who died on July 25, was born in Lofta, Sweden, in 1893 and was educated in the University of Upsala, graduating M.D. in 1926. It was in Upsala where his career was spent, for he was director of the Statens Rasbiologiska Institut there from 1936 until his death. He was also dean of the Faculty of Medicine at Upsala during the critical year 1939–40 when Swedish mobilization faced the University with administrative problems, into which he threw his energies with enthusiasm as one of the leading Swedish intellectuals with uncompromising hostility to the Nazi challenge. From the start a vigorous critic of the Nazi creed, he was at all times a friend of the British cause when the Second World War became inevitable. In 1948 he received from Britain the King's Medal for Service in the Cause of Freedom in recognition of the part he played.

As a man of science, Dahlberg is remembered for his early work on twin resemblance, his pioneer publications on the genetical theory of inbreeding and more especially for his concept of the population isolate. Above all, he strove to develop human genetics as a branch of medical science dissociated from its discreditable associations with racialist propaganda. He edited a monumental semi-popular

encyclopædia sponsored by the Swedish Red Cross Society. He was the author of an important book on vital statistics, "Sjukdomarna och Samhällhet", and also a popular book translated by Lancelot Hogben under the title "Race, Reason and Rubbish". In 1953 the *Acta Genetica et Statistica Medica* celebrated his sixtieth birthday by publishing a memorial volume to its editor.

Among Dahlberg's many honours were an honorary LL.D. of Aberdeen (1938) and a doctorate of odontology (*honoris causa*) of Stockholm (1955). He received the Alvarenga Prize of the Swedish Medical Association in 1929 and a prize award in 1933 from the King Oscar II Jubilee Fund. He is survived by his widow Stina (*née* Westberg), whom he married in 1919.

NEWS and VIEWS

Mathematics at the Imperial College, London : Dr. Abdus Salam

Dr. Abdus Salam, lecturer in the University of Cambridge, has been appointed to a University chair of mathematics at the Imperial College of Science and Technology, London. Dr. Salam is a brilliant mathematician with an international reputation in the field of theoretical physics. He has played an important part in the development of quantum electrodynamics and the various theories which have been formulated to interpret the properties of mesons and other recently discovered fundamental particles. His activities in these directions will be especially appreciated at Imperial College, where he will find colleagues with an active interest in the experimental side of such investigations. Dr. Salam received his early education at the University of the Punjab, where he took the M.A. degree in 1946. In 1948 he graduated at Cambridge and was awarded the Ph.D. degree of that University in 1951. In the same year he was elected to a research fellowship at St. John's College, Cambridge. Dr. Salam has previously held high appointments in mathematics. In 1951 he became professor of mathematics at Government College, Lahore, and in 1952 was appointed head of the Department of Mathematics in the University of the Punjab. Since 1954 he has been a lecturer in the University of Cambridge and acted as scientific secretary at the Geneva Conference in 1955 on the peaceful uses of atomic energy.

With the appointment of Prof. Salam, there are now four professors in the Department of Mathematics in the Imperial College, namely : Prof. H. Jones, who is the head of the Department ; Prof. G. A. Barnard, professor of statistics ; Prof. W. K. Hayman, professor of pure mathematics ; and Prof. A. Salam, who will be concerned mainly with applied mathematics and mathematical physics.

Pan-American Foot-and-Mouth Disease Centre, Rio de Janeiro : Dr. W. M. Henderson

Dr. W. M. Henderson, deputy director of the Research Institute (Animal Virus Diseases), Pirbright, Surrey, has been appointed director of the Pan-American Foot-and-Mouth Disease Centre, Rio de Janeiro, Brazil, and is taking up his duties in January. This international centre began in 1951 as a Technical Co-operation Project of the Organization of American States. The operation of the Centre is the responsibility of the Pan-American Sanitary Bureau, which is the regional office of the World Health Organization. The work of the Centre is the training of national laboratory and field staffs responsible for the control of foot-and-mouth disease in the Americas, the provision of a field consultation and confirmatory diagnostic service and research. It is now intended to expand the research facilities and activities.

Dr. Henderson, who is forty-three, was educated at the Royal (Dick) Veterinary College and the University of Edinburgh and qualified in 1935. During 1936–39 he was assistant to Prof. George F. Boddie, professor of medicine in the Royal (Dick) Veterinary College, Edinburgh. In January 1939 he was appointed research officer to the Pirbright Research Institute to work on foot-and-mouth disease and other vesicular diseases of animals. When the post of deputy-director was created in 1955, his abilities were recognized by his selection for the post. During his seventeen years at the Institute, Dr. Henderson has made outstanding contributions to the advancement of knowledge on foot-and-mouth disease. He has been responsible for developing new methods which are now recognized as standard procedures for research on the disease and for the control of the preparation of vaccines. He was awarded the degree of D.Sc. of the University of Edinburgh for a thesis on the "Quantitative Study of Foot-and-Mouth Disease" ; and the method of virus estimation with which this deals is now known as Henderson's method and is widely used in many research institutes.

First Companion Members of the Textile Institute

Under by-laws authorized by the supplemental royal charter granted to it last year, the Textile Institute is empowered to elect as companion members (Comp.T.I.) those of its members who in the opinion of the Council have substantially advanced the general interests of the textile industry. The Council has announced the first conferment of this honour to the following seven members, who will be formally admitted by the President at the Institute's convocation in Manchester on October 26 : Mr. James Ewing, chairman and joint managing director of the Bradford Dyers' Association, Ltd. ; Sir Ernest Goodale, chairman and managing director of Warner and Sons, Ltd., London, and past president of the Institute ; Mr. H. G. Greg, chairman of R. Greg and Co., Ltd., Reddish ; Sir John Hanbury-Williams, chairman of Courtaulds, Ltd. ; Mr. J. A. Nasmith, vice-president of the Universal Winding Co., and a former chairman of Council of the Institute ; Mr. S. F. Peshall, of N. Corah and Sons, Ltd., Leicester ; and Sir Raymond Streat, chairman of the Cotton Board and past president of the Institute.

The Realm of the Nebulæ

It was the astronomer Edwin Hubble who said that the history of astronomy was a history of receding horizons. While research at the limit of distance remains as important as ever, developments during the past two decades have emphasized the necessity of studying the physical nature of the extragalactic nebulæ as well as their motions and distribution. This is exemplified by the articles in the September 1956 issue of the *Scientific American*,

the whole of which is devoted to astronomy as related to cosmology. The fundamental discovery of the two stellar populations has shed light on the evolutionary history of a galaxy, and this has been reinforced by studies of the origin of the chemical elements and of the nuclear processes which take place in stars. Astronomers are now aware of the basic nature of interstellar material as the source of the bright stars of Population I, and when a collision of galaxies occurs the interstellar matter which they contain is the seat of the optical and radio emissions which are observed. A decision between evolutionary and steady-state cosmologies is much to be desired; measurement of the red-shifts of more distant nebulæ, identification of additional distant colliding galaxies as radio sources, further investigations on the large-scale distribution of galaxies, all may contribute to the decision. Observational programmes now in progress may indeed provide the essential data for the solution of the cosmological problem.

Occultations of Radio Sources by the Moon

A PAPER, by F. Link, entitled "Occultations des Radiosources par la Lune et Phénomènes Connexes" (*Bull. Astro. Instit. Czechoslovakia*, **7**, No. 1; 1956), deals with the possibility of occultations by the Moon of radio sources and shows the existence of a very rarified lunar atmosphere. In an earlier publication (**5**, 112; 1954) Link directed attention to a series of such occultations between the years 1955 and 1957, and C. L. Seeger has also directed attention to the same subject (*Trans. Int. Astro. Union*, **8**; 1952). The investigation has more than an academic interest, and Link refers to four matters which are of great interest and importance: the exact determination of the positions of radio sources; the determination of the photometric profile of radio sources; the discovery of new feeble radio sources; and possible proofs of the lunar ionosphere. As the last-mentioned can modify the interpretation of the first three points, it is dealt with first in the paper. Link points out that different attempts based on the optical properties of the lunar atmosphere have not so far led to definite results. Lyot and Dollfus, by measuring with the coronagraph the brightness in the vicinity of the Moon's horns at the first quarter, estimated the superior limit of the density relative to that of the Earth's atmosphere at sea-level as 10^{-8} approximately. Dollfus, continuing with the investigations and basing his research on the polarization of the light diffused by the hypothetical atmosphere of the Moon, obtained a limit of about 10^{-9}, while Kuiper, using the spectroscopic method to detect traces of sulphur dioxide, gave the mass of a vertical column of this gas the upper limit 3×10^{-10} that of the terrestrial atmosphere. Other attempts by Lyot and Dollfus by the method previously described did not give such low limits. Link investigates the subject, starting with the two factors that determine the existence of any ionosphere—terrestrial or lunar; these are the presence of gases capable of being ionized, and the ionizing solar radiation. Examining these two factors on the Earth and on the Moon, his mathematical investigations lead to the suggestion that a lunar atmosphere of density 10^{-12} that of the terrestrial atmosphere at sea-level might give observable phenomena such as the deviation of the rays and the augmentation of their intensity. It is admitted at the end of the paper that it is premature at present to pursue these general considerations, their aim being merely to direct attention to occultations of radio sources and the phenomena which can accompany them.

Water Resources of Great Britain

THE problem of water conservation and flood control in Britain is receiving increasing attention by the authorities concerned (see *Nature*, **176**, 1133; 1955) and, in particular, has become more widely recognized during the present year as a result of the contrasts of water shortage during a dry winter and much recurrent flooding in the course of a wet summer. The publication of the "Surface Water Year-Book of Great Britain, 1953–54" (pp. 117. London: H.M.S.O., 1956; 30*s*. net) is a welcome reminder of the work now in hand to assess the water resources of the country on a more scientific basis. This publication of the Ministry of Housing and Local Government and of the Scottish Office gives hydrographic statistics for British rivers, together with related rainfalls, for the year ended September 30, 1954, and is the first of the intended yearly issues covering periods of one water year. The two previous publications embraced eight years each, and the records were somewhat patchy and broken. The new annual issue will, it is hoped, ensure both uniformity and continuity. The new volume contains the flow records of a hundred and two stations, has the daily discharges of most, and includes discharge frequencies for certain selected stations. A new feature is the inclusion of natural water temperatures of the River Test in Hampshire and the River Avon in Somerset. It is hoped to extend these observations into a network of temperature-recording stations which will eventually provide standards of comparison to which intermediate observations, in place or time, may be related.

Standard Capacitors and their Accuracy in Practice

No. 13 in the series of "Notes on Applied Science" of the National Physical Laboratory, Teddington, which is on "Standard Capacitors and their Accuracy in Practice" (pp. 10. London: H.M.S.O., 1955; 1*s*. 3*d*. net), directs attention to the various factors which affect the performance of capacitors, both by virtue of their construction and by their method of use. The booklet is primarily concerned with capacitors designed for use as laboratory standards, and the information given is based on the wide experience gained in testing and using such instruments over many years at the Laboratory. Both air-dielectric and solid-dielectric capacitors are discussed, and separate sections deal with the inductance and resistance of capacitors and with the effects of leads on the measured values of the capacitances. Good-quality capacitors, whether with air or mica dielectric, it is concluded, provide a standard of reactance not greatly inferior in constancy to that of a good resistor, provided that proper precautions are taken in their maintenance and use. Clamped mica capacitors of between 0·1 and 1 μF. are probably the most stable, and if they are kept under moderate and uniform conditions of temperature and humidity the fluctuations about their mean values should not be more than $\pm$ 0·5 part in 10^4 on capacitance and $\pm$ 20 per cent on power factor, over a period of several years. The capacitance of a capacitor of simple geometric shape can be calculated from its linear dimensions and from the dielectric constant of the material be-

tween its electrodes, and thus in theory it should be possible to make an absolute standard of capacitance against which all other capacitors can be compared. However, absolute standards of inductance can be designed and constructed with considerably greater accuracy, and measurements of capacitance are ultimately based, in conjunction with a frequency standard, on the Campbell standard of mutual inductance which is the absolute standard of reactance at the Laboratory.

Catalogue of Nuclear Reactors

The Chalk River Project of Atomic Energy of Canada, Ltd., with the co-operation of the Atomic Energy Research Establishment, Harwell, has prepared a "Catalogue of Nuclear Reactors 1955" (AECL No. 220; CRR-590. Pp. 60. London: H.M.S.O., 1955; 4*s.* 6*d.* net), which has been compiled from the unclassified literature and refers to reactors that are known to have reached criticality by July 1955. The catalogue includes reactors in Canada, France, Great Britain (BEPO, DIMPLE, GLEEP and ZEPHYR at Harwell and the two reactors at Windscale), Norway, Sweden, Switzerland, the United States (about forty reactors, including six at Arco, Idaho, and nine at Hanford, Washington) and the U.S.S.R. The details given for each reactor consist of brief notes covering six items —neutron speed; fuel configuration; kind of moderator; purpose (research, power, etc.); thermal power; and neutron flux—as well as constructional details and one or two useful references. Additions to, and revisions of, the catalogue will be prepared from time to time in order to keep the collection of data up to date.

Chemistry Films

A special issue of the *Scientific Film Review* catalogues films on chemistry and allied topics (2, No. 2; June 1956). The list is derived from one compiled by the Scientific Film Association in 1949 and includes the appraisals then prepared by the Association's viewing committee. To the appraisals have been added films from many recent catalogues, one or two reviews and some foreign films. For the catalogue, chemistry has been widely interpreted so that no known film likely to be of use has been omitted. Among the sections for which films are included are agriculture, atomic physics, crystallography, laboratory techniques, industrial manufacturing processes, microscopy and public health.

International Abstracts of Biological Sciences

The Council of Biological and Medical Abstracts, Ltd., has decided to change the title of its journal *British Abstracts of Medical Sciences* to *International Abstracts of Biological Sciences*. This decision has been brought about, first, by an extension of the scope of the *Abstracts* to a wider range of biological research subjects published in journals throughout the world, and, second, by the fact that the *International Abstracts of Biological Sciences*, with the co-operation of the specialist editors selected by the Institute of Scientific Information of the Academy of Sciences of the U.S.S.R., will include, as from the January 1957 issue, translations of important Russian papers abstracted in the *Referativny Zhurnal Biologii* (Soviet biological abstracts) and *Referativny Zhurnal Biologischekoi Khimii* (Soviet abstracts of biological chemistry), to be published simultaneously with their appearance in Russian. The *Abstracts* are published for the Council of Biological and Medical Abstracts, Ltd., by the Pergamon Press, of London and New York, on a non-profit-making basis, and the honorary editor is Dr. C. C. N. Vass. Since the Russian abstracts will have to be translated, the Council requires translators with knowledge of anatomy, animal behaviour, biochemistry, endocrinology, experimental biology, experimental medicine, microbiology, odontology, pathology, pharmacology and physiology, and would welcome offers of help. Terms of payment and other details can be obtained from Dr. C. C. N. Vass, c/o Pergamon Press, Ltd., 4–5 Fitzroy Square, London, W.1, or 122 East 55th Street, New York 22, N.Y.

Political and Economic Planning

In Broadsheet No. 400, entitled "PEP 1931–56" (*Planning*, 22, 141; July 23, 1956; 2*s.* 6*d.*), Political and Economic Planning explains its purpose and methods of working, emphasizing particularly the dependence of its success on the anonymity of the groups and the insistence on the importance and nature of research in relation to public affairs. For each study it has brought together both experts skilled in various aspects of the subject under study and laymen chosen for their ability to ask the necessary questions and to hold the balance between conflicting specialists whenever necessary. For the most part, PEP has concentrated on research into the results of available research and into material and experience already gathered for other purposes, except where first-hand sample investigations have been essential. For the past two years, PEP has been engaged on two projects financed under the Conditional Aid Scheme for the Use of Counterpart Funds derived from United States economic aid. A report on the first, which will provide accounts of the work of particular trade associations and their relation with individual firms and public corporations, is due for publication later this year. The second consists of a survey of the employment entered by men graduating in a selected year, 1950, which is also to be published this autumn under the title "Graduate Employment", and a survey of the policy and practice of industrial undertakings in employing graduates. PEP is also engaged on two other major studies: one, expected to take three years, on adaptation in industry; and the other on family needs and the social services. The present broadsheet suggests that the fundamental strength of Political and Economic Planning is in its intellectual initiative and possession of the necessary qualities and resources to continue pioneering new fields and new techniques; but the report emphasizes the need for regular income and for more subsidies if the volume and quality of the work are to be maintained.

Training for Supervisors

"If we are going to be really effective in world competition, then we must make for greater efficiency and one of the ways of doing so is by having better supervision." These are among the concluding words of a discussion between five people from different spheres of industrial life recorded in a booklet called "Training for Supervisors" which has been issued by the Ministry of Labour and National Service. The five people—a training officer, general manager, director, production superintendent and shop foreman—met to express their views on the conclusions of the 1954 Report of the Committee

of Inquiry on the Training of Supervisors and relate these conclusions to their own experience in industry.

The group was in general agreement on three points. First, that the responsibility for training supervisors is one for senior management; second, that industrial training is ineffective if it is of a purely academic character; and third, it is no good giving the supervisor training if his status is not right in the firm. He must be regarded as a member of the management team. The booklet has been prepared in collaboration with the Central Office of Information and with the aid of a grant made available under the Conditional Aid Scheme for the Use of Counterpart Funds derived from United States economic aid. It is not for sale; but copies can be obtained on request from the Director of Public Relations, Ministry of Labour and National Service, 8 St. James's Square, London, S.W.1. The other booklets in the series deal with joint consultation in industry, the spreading of information in the factory and personnel selection.

Scientific Research at South African Universities during 1955

THE fourth volume of the "Register of Current Scientific Research at South African Universities" covers research conducted during 1955 (pp. 341. Pretoria: Council for Scientific and Industrial Research). The investigations described are arranged under the name of the university department concerned, which is listed alphabetically according to its English name, with occasional subject cross-references. The actual information is given in the language in which it was received from the universities; but headings and sub-headings are in English only, and this year an English translation of the subject of research submitted in Afrikaans is included. Agricultural chemistry and agricultural engineering are indexed as sub-sections of agriculture, and all chemistry entries are entered under the one general heading of chemistry (inorganic, organic and physical). Academic degrees and full professional qualifications are given where these are ascertainable. The volume contains 545 entries.

Royal Scottish Museum, Edinburgh: Report for 1955

THE annual report for 1955 of the Royal Scottish Museum, Edinburgh (pp. 16; from the Museum; 1956), is a record of steady progress, especially in the related work carried out for cultural and educational institutions. Following the example of the director, Dr. D. A. Allan, who has contacts both at national and international levels, members of the senior staff have made many personal contributions to a wide variety of educational and cultural organizations in the field of museum work. It is unfortunate that the long-needed lecture hall is still in the drawing-board stage.

Government Museum, Madras: Report for 1954–55

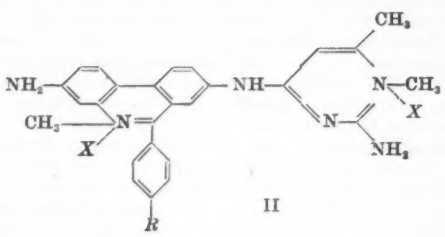
THE annual report of the Government Museum, Madras, for 1954–55 (pp. 46+2 plates. Madras: Government Press, 1956) records the excellent educational work which is being undertaken by this progressive institution. Certain students in the University of Baroda have been given detailed instructions in museum methods, while other students of the University of Madras were provided with practical demonstrations in anthropology. Despite a limited staff, much preservation work has been carried out, especially in the chemical conservation section where experiments were made concerning the electrolytic method for cleaning coins.

French Metallurgical Society

THE French Metallurgical Society will hold its autumn meeting in Paris at the Maison de la Chimie during October 22–27. At the meeting the following awards will be presented: the Grand Medal of the Society, to Prof. R. F. Mehl for his work, in general, on metallurgy; the Sainte-Claire-Deville Medal, to R. Gadeau for his work on aluminium of high purity; and Rist Prizes, to F. Montariol and J.-P. Moreau. A special feature of the meeting will be a series of papers on non-destructive methods for the study and control of metals. Further information can be obtained from the Société Française de Métallurgie, 25 rue de Clichy, Paris 9e.

"Prophylaxis of Trypanosome Infections in Cattle"

MESSRS. T. I. Watkins and G. Woolfe state that, in their communication under this title published in *Nature* of August 18, p. 368, they gave an incorrect structure for compound II. The correct structure is



II

Announcements

MR. R. E. GLOVER, principal and dean of the Royal Veterinary College, has been appointed a member of the Agricultural Research Council in succession to Prof. G. R. Cameron, who has resigned; Prof. S. J. Watson has been appointed for a further term as a member of the Council and will continue as deputy chairman.

THE fifth annual convention of the Scientific Instrument Manufacturers' Association will be held in Eastbourne during October 11–14, under the general theme of "Production 1957". There will be four panels on the following topics: general, optical and mechanical production; electrical and electronic production; research and development; and marketing. The guest speaker on the opening day will be Mr. Stanley J. Harley, of the Coventry Gauge and Tool Co., Ltd. Further information can be obtained from the Association at 20 Queen Anne Street, London, W.1.

A CONFERENCE on "Gas Turbine Development", arranged by the Department of Engineering of the North Herts Technical College, Broadway, Letchworth, will be held in the College during October 20–21. There will be four papers, covering the development of the gas turbine in the following respective fields: industry; motor vehicles; ships; and aircraft. Further information can be obtained from the North Herts Technical College.

SCIENTIFIC CINEMATOGRAPHY IN GREAT BRITAIN

THE second Research Film Programme of the British Association, held at Sheffield on September 1, was opened by S. Bowler, vice-president of the Royal Photographic Society, by strongly supporting the idea of a central institute after the style of the German Institut für den wissenschaftlichen Film in Göttingen in order to raise the general standard of British research films. He was seconded by Dr. A. R. Michaelis, who had again organized the meeting on behalf of the Scientific and Technical Group of the Royal Photographic Society. Dr. V. G. W. Harrison was in the chair during the meeting, which was well attended by an audience numbering about 350 in the morning and more than 200 in the afternoon.

Outstanding among the work presented to the meeting were the two research films made by the strong team at the Chester Beatty Research Institute and University College, London. On behalf of the team, composed of P. C. T. Jones, K. Moreman (the cinematographer), D. M. Easty, M. Abercrombie and J. Santler, Dr. E. J. Ambrose introduced their film on "Interference Microscopy of Living Cells in Tissue Culture No. 2", in which epithelial cells were compared with certain carcinoma cells which develop from epithelium; interference cinemicrography in time-lapse frequency was employed throughout. This allowed not only a very clear appreciation of cytological phenomena but also often presented scientific material of great æsthetic beauty. He showed that, irrespective of their source of origin, epithelial cells formed very strong surface adhesions with each other, as distinct from carcinoma cells which moved quite independently, thus demonstrating a marked surface difference between these two types of cells.

Certain physico-chemical tests were carried out to substantiate this difference, and the negative electrical charge on the cell was measured in the presence and absence of various positive ions. The variations in the rate of movement of protein through the cell membrane in the presence of antiserum was also determined, and these changes were clearly seen in the film as rapid colour transformations in the cytoplasm of the compressed cells. The second research film from the Chester Beatty Research Institute was presented by R. J. Goldacre; it was entitled "New Aspects of Amœboid Movement". It was also recorded at time-lapse frequency, using partly phase-contrast and partly interference cinemicrography. Mechanical interference with the regulating mechanism of the polarity-conditioned locomotion of amœbæ led to the discovery of three new kinds of movement which were shown in the research film: first, rapid cytoplasmic oscillations with a frequency of 1–2 cycles per second and amplitude of 4–20 microns; secondly, cell rotation with suppression of noticeable cytoplasmic streaming and of locomotion; and thirdly, the transmission of contraction from one end of the cell to the other. In addition, interference cinemicrography was employed to investigate ingestion of phagocytosed prey by food vacuoles.

Bacterial swarming was the subject of a further interesting biological research film, presented by Drs. P. N. Cardew and H. Hughes, of the Wright–Fleming Institute and the Medical School, St. Mary's Hospital, London. It was called "The Swarming of *Proteus vulgaris*", and again time-lapse cinemicrography was employed. The growth of a single cell into a colony was followed, both on the plate and microscopically; the movements of abnormal long forms and details of swarming were clearly demonstrated. Further sequences dealt with the mutual interference of incompatible strains due to the production of primary toxic products and due to a second toxic influence, the accumulation of peroxide. That time-lapse cinemicrography is not confined to biological research topics was shown in the research film sent to the meeting by J. Newkirk, of the General Electric Company, Schenectady; it dealt with the growth, evaporation and phase-transformation of mercuric iodide crystals. The excellent use of colour in this film allowed an exceptionally clear understanding of the phenomena under investigation.

The interesting cinematographic technique of time-sampling was demonstrated in two films. The first, by J. Robertson, of the Tavistock Clinic, showed the behaviour of a two-year-old girl in hospital, when deprived of maternal care. At standard times during the day for regular intervals over 40-minute periods, the patient was filmed in order to obtain an objective record of her behaviour. Extracts from this scientific film, introduced by its author, showed clearly the marked difference in the child's behaviour when left to itself—fretting and depressed—and when playing with its mother during her visits—happy and contented. Next, Dr. P. Sainsbury, of the Westminster Hospital, presented his research film, "A Method of Measuring Spontaneous Movements by Time-Sampling Motion Pictures". He employed it as a quantitative technique for counting the gestural movements of his patients before and after leucotomy and of other patients with nervous tics; these movements are of a kind which cannot be counted individually. A signal lamp was mounted out of view of the patient to flash at 5 or 2½ sec. intervals. Those intervals were counted as positive during which the specified movements occurred; when these movements were absent, the interval was scored as negative. Extracts from his research records were shown, demonstrating a decrease of gestural movements nine months after leucotomy. Further sequences dealt with the frequency of nervous tics of a number of patients during a variety of situations.

Colour schlieren cinematography at standard camera frequency was employed in the excellent film, "High-Speed Flow Around a Symmetrical Aerofoil", recently recorded by S. Beadle, of the Shell Film Unit at the Aerodynamics Division of the National Physical Laboratory, and introduced by A. Chinneck. Both at sub- and at super-sonic velocities, the movements of shock waves and the separation of the boundary layers were beautifully demonstrated, particularly when the air flow was increased from sub- to super-sonic velocities. The effect of changes of the angle of incidence of the aerofoil was also filmed. Cinematography at normal camera frequency has proved in the past of great

value to record an experiment, which is unique, or difficult to repeat. A recent example of such use was the film "The Release of Cosmic Ray Balloons", made and introduced by J. H. Davies, of the H. H. Wills Physical Laboratory, University of Bristol. Balloon launchings extending over several years in Great Britain and abroad were filmed, and by careful analysis of these records it was possible to improve the technique considerably. The initial acceleration of the rising balloon could be reduced considerably by the use of a winch instead of employing many open-ended sandbags. Similarly, an undesirable mushrooming effect, leading to very high stresses in the envelope, could be eliminated by using a cord of undrawn nylon which stretched to several times its original length and thus allowed a gentle lifting of the heavy load.

High-speed cinematography was employed in three research films presented to the meeting. Wing Commander F. Latham, of the R.A.F. Institute of Aviation Medicine, Farnborough, began with unassisted escape from aircraft, showing the limitation of whole-body movements under sustained acceleration by comparing dummy and live-body trajectories on meeting high-speed slip streams at the commencement of free fall from aircraft exits. Camera frequencies up to 200 ft./sec. were used. The second stage, namely, of assisted escape from aircraft in the form of seat ejection, was similarly filmed and allowed a detailed physiological investigation of the tolerance of the human body to vertical impact acceleration and high-speed wind blasts. "Experiments of Sideways Launching" of ships was the next film to employ high-speed cinematography. It was extremely well recorded by C. A. Guthrie, of the Central Photographic Section of the National Physical Laboratory, often under most trying conditions. Scientific direction of this work was the responsibility of D. J. Doust, and the film was introduced by R. Silverleaf, both of the Ship Division of the National Physical Laboratory. The main problems concerned the possibility of capsizing due to insufficient stability, structural damage, and hull pressure due to impact. Full-scale launchings were filmed, sometimes from several different camera positions at the same time, and similarly model experiments with 1/18 scale models were recorded. From such experiments and these films, the performance of a variety of hull forms at launching can now be predicted and dangerous conditions of stability, way-end velocity and static drop can be avoided.

The only industrial research film presented at the meeting also employed high-speed cinematography, at a camera frequency of 1,000 ft./sec. It was made in colour and introduced by J. Underwood, of the Guest, Keen and Nettlefolds Group Research Laboratory. It dealt with "Flame Movement in an Open Hearth Furnace during Tapping" and was taken to investigate the causes of local overheating; from the resulting records it was possible to direct the research into profitable channels. During tapping the furnace is tilted, and from the research films made during this process, it became clear that the flame was not homogeneous, that patches of unburnt oil remained, and that the existence of turbulent edges showed undesirable changes of the aerodynamic conditions.

A number of comments may be submitted in this report. Out of the eleven presented, only one research film would find undisputed international acclaim—that introduced by Dr. Ambrose. Apparently only one research worker, Dr. Sainsbury, has used scientific cinematography in a metrical manner and has derived quantitative data from his research film; the majority of those presented could have been submitted to frame-analysis and would have yielded a mass of scientific information, completely lost by mere projection and visual inspection of the film. In nearly all cases a professional photographer or cinematographer was employed in the production of each film; yet much could be said in detailed criticism. These comments are strong support for the creation of a central institute from which advice, comment and specialized equipment could be obtained.

However, the general picture is encouraging and in the years to come may lead to an improved position. There can be little doubt that the aims of the organizers of this meeting were fulfilled by presenting a selection of the best research films available to an audience of scientists at the British Association. A third meeting is planned for September 7, 1957, at Dublin, and the hope can only be reiterated in this article that all those who have made new research films in the meantime will present their results; the films should be submitted to either the Scientific and Technical Group of the Royal Photographic Society or to the Scientific Film Committee of the British Association.

A. R. MICHAELIS

CLIMATOLOGY IN THE SERVICE OF MAN

AT the Sheffield meeting of the British Association, Section E (Geography), under the presidency of Prof. A. Austin Miller, of the University of Reading, devoted a day to a series of contributions on "Climatology in the Service of Man", which might well be regarded as a very appropriate development following the presidential address (summarized in *Nature*, September 1, p. 474).

Prof. G. Manley opened by directing attention to the growing economic significance to Britain of the fact that we now import about 4 per cent of our fuel as coal or its equivalent. This is about equal to the difference in the requirement of fuel for heating purposes imposed by a severe season as compared with a mild one—the season comprising the months September–May. Variations in demand show an approximately linear relationship with the accumulated deficit of mean monthly temperature below a value which he took as 57° at sea-level. Official statistics of annual means back to 1866 have already been used in studies of variations in fuel demand; but for England and Wales monthly means are only available from 1901. Prof. Manley stated that his purpose was to extend our knowledge of the vicissitudes; he showed that a table of monthly means (*Quart. J. Roy. Met. Soc.*, 1953) giving representative values for the past 250 years now provides a reasonable index of the probable fluctuations of the heating requirement for the greater part of Britain. He directed attention to the occurrence in late Victorian times of the combination of a severe winter with a protracted cold spring, which if repeated would set up demands in excess of any seasons so far experienced this century, in which 1916–17 and 1950–51 gave the highest values. The highly irregular incidence of severe seasons gives as yet little reason for supposing that a protracted cold season such as occurred in the

1880's may not occur at any time. The need for further climatological research assumes greater urgency in view of our precarious fuel position.

Mr. M. Parry, of the University of Reading, followed with an appropriate reminder of the factors governing heat losses from a house. His remarks were based on studies made by the Building Research Station. Using the standard technique of degree-days, he then presented useful data from Reading, Bath and Nottingham to show the differences in fuel requirement likely to arise between houses of similar type, within and without the built-up area. Making further allowances for the wind factor, local variations of the order of 25–30 per cent in the annual fuel bill can be expected. Urban studies were rewarding.

Dr. Alice Garnett directed the attention of the audience to a variety of published studies in regard to atmospheric pollution, and went on to demonstrate the unpleasant—indeed disturbing and potentially lethal—accumulations which might be set up in certain parts of the Sheffield area, where a number of gauges have been established. Here she made effective use of maps indicating the association with local relief. She drew emphatic conclusions regarding the need for very close study of the problems which might arise from the siting of new 'industrial zones' in an area with such well-marked relief and a day-and-night outpouring of smoke.

Miss E. M. Frisby, who is working with a well-known commercial advisory and consultant organization in the United States, summarized the way in which climatological information can be presented for the use of various clients engaged, for example, in building construction in remote country, or in the processing of food crops. The comment was made that in Britain such provision of information is a public service.

The afternoon papers were primarily concerned with evaporation. Mr. G. Melvin Howe (Aberystwyth) demonstrated maps of seasonal water surplus and deficit, based on the Thornthwaite formulæ, for England and Wales. Clarity in cartographical representation is a valuable service which the geographer can and does render; a comment, however, might be that the representative character of the fundamental statistics used might be questioned in view of the local characteristics of stations to which Mr. Parry had earlier directed attention. Mr. S. Gregory (Liverpool) re-emphasized the need for water storage and conservation. In reminding the audience that since H. R. Mill geographers had taken little interest in rainfall, he summarized the type of work already done and stressed the need for further cartographical studies, especially in the north of England, where industrial demand for water is rising much more rapidly than was forecast.

Prof. B. J. Garnier, of Ibadan, brought in a welcome contribution from overseas. Irregular incidence of the short bursts of intense rainfall in Nigeria, coupled with very high evaporation, seldom much less than 4 mm. daily, explain why a slight deficiency is quickly felt. He showed how in relatively well-watered country irrigation may nevertheless be very valuable, especially as the increase in the population will soon necessitate more intensive production of food.

Mr. J. L. N. Sibbons (Sheffield), at the end of the session, taxed the non-mathematical part of the audience; he gave a carefully reasoned demonstration of the difficulty of determining the potential loss of moisture under specified climatic conditions. He showed that the assessment of evaporation-losses by the Thornthwaite method breaks down in certain unusual climates. From another point of view he showed that Penman's approach is also open to some criticism; and, taking account of Sir Graham Sutton's work, he proposed equations which would give better estimates. This was a bold and well-reasoned paper in an exacting field, and it is to be hoped that Mr. Sibbons's ideas will find outlet in print; at least one expert from the Meteorological Office was observed to be engaged in animated comment on the equations on the board.

The papers were varied, and served at least one useful purpose, in that they showed the value, as a shorthand summary of results and as a stimulus to discussion, of well-drawn maps and diagrams, although at times the observational basis may be open to question. Many in the audience were perforce little acquainted with the numerous specialized studies now forthcoming from various sources and research groups. The critically minded geographer can render a useful service in assembling and filtering such material. The geographical approach, moreover, can be illuminating, in that the results of scientific investigations can be related to a particular area and tested by the members of the audience against their own direct field-experience and observation elsewhere.

INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

CONGRESS IN OXFORD

THE Twelfth Congress of the International Union of Forest Research Organizations was held in Oxford during July 7–14 under the presidency of Prof. Aldo Pavari, of Florence. At this, the first occasion on which the Union had held a Congress in Britain, about 250 delegates attended, from forty-two different countries. The Union, which was founded in 1890, is an association of forest research institutes, including universities, industrial research stations and State institutes, and its main purpose is to advance research into forestry problems. Originally a Union of Central European stations, it has steadily expanded until it now has members in all parts of the world; it is still attracting new recruits, and among recent accessions are the Academy of Sciences of the U.S.S.R. and the research stations of the Forest Service of the United States.

Most of the meetings of the Congress were held in the Imperial Forestry Institute; but the opening and closing ceremonies took place in Regent's Park College, Oxford. The Congress was formally opened by the Minister of Agriculture, Fisheries and Food, Mr. D. Heathcoat Amory, who spoke about forest policy in Great Britain and the place which research has taken in recent developments. He mentioned that much of the earlier effort was devoted to establishing crops of trees on land which had carried no tree growth for centuries; after about thirty years of effort, many of the problems of establishment have been solved, and British research workers are now turning their attention to the problems of managing forests. Work study and mechanization are being dealt with, and much interest is being taken in the effect of trees on the soil. Mr. Amory

also referred to research into the qualities and properties of timber, a subject most essential to foresters, who must never lose sight of market requirements.

The work of the Congress was carried out in Sections, of which there are nine, each dealing with a different subject, and discussions continued during the week, except for a break on July 12 when delegates visited Rothamsted Experimental Station, the Forest Products Research Laboratory at Princes Risborough and the Forestry Commission's Research Station at Alice Holt, near Farnham.

The section leaders, who continue in office between Congresses, are responsible for keeping in touch with all the research workers in their respective fields of action, for circulating information of interest to members of their Section and for initiating action when this is necessary. The Section on Forest Influences, under Sir Harry Champion, of Oxford, dealt with two main subjects: the effects of shelter belts on agricultural and horticultural crops and on livestock; and the effect of forest growth on water supplies. On shelter, it was recommended that there should be an expansion of research into the influence of different types of shelter-belt on crop yields, using modern statistical methods wherever possible; in this work, closer contact with those engaged in plant and animal husbandry is of great importance. More information is needed on the effect of tree roots on agricultural crops under various conditions, on the shelter effect of scattered trees and groups of trees on pasturage and on the influence of systems of shelter belts on regional climates. The effect of forest cover on water supply is a difficult subject to treat experimentally, and the Section recommended the setting-up of a working party to study research methods and procedures. Attention was directed to the lack of comparative watershed data from the more tropical dry or seasonally dry regions, and the need was stressed for a study of the theoretical foundations and the practical application of the concept of evapo-transpiration. The Section also asked member institutes to pay more attention to research on forest influences in the humid tropics.

Under Prof. A. de Philippis, of Florence, the Section on Site Factors dealt with plant communities and their importance to practical forestry. With the help of phytosociological methods, there are many problems which can be solved quickly as, for example, the improvement of indigenous stands, the acceleration of forest successions, the conversion of forests to more favourable sylvicultural types, and the choice of species for forest plantations. The Section recommended that rules of international application should be drawn up for uniform methods of forest mapping and for uniform procedure in classifying and naming forest communities.

Dr. C. Syrach Larsen, of Denmark, and the Section on Forest Plants, spent some time in a discussion on teak, as a result of which further work on the flowering of this tree was called for as well as provenance trials. There was some discussion on the selection of stands and single trees for seed production and tree breeding, subjects in which there is at present a wide interest. Some countries, among them Great Britain, have started to compile registers of individual trees and of crops of trees which are suitable sources of seed, and the Section recommended that countries which had not started on this work should begin forthwith. Subjects to which special attention should be paid before the next Congress are methods for the mass production of seed, the place of the Mexican pines in sylviculture and provenance types of Douglas fir.

The Section on Sylviculture, under Prof. H. Leibundgut, of Zurich, dealt with methods of classifying trees and spent some time in discussing how to assess the effect of various methods of tending forest crops on growth and quality. The wide field of practical sylviculture was also dealt with.

Dr. H. van Vloten, of Wageningen, leader of the Section on Forest Protection, dealt with research into population dynamics and discussed virus diseases of insects of importance in forestry. The possibility was also examined of securing international co-operation in making trial plantations of important tree species in several continents in order to study resistance to diseases and pests.

The Section on the Study of Growth, under Prof. Y. Ilvessalo, of Helsinki, considered the methods of studying yield and growth in forest crops, the varjations in yield arising from climatic factors and the determination of the amount of timber which may be cut. It was agreed to form a working-group to examine the possibility of standardizing methods of measurement and to consider how best to circulate information on instruments used in forest mensuration.

Prof. J. Speer, of Munich, presided over the Section on Forest Economics, which dealt mainly with costs in forest operations. In this field, terminology is of importance if the performance in one country is to be compared with that in another, and the Section decided to study this subject with the view of clearing up the obscurities which exist at present. It was also agreed to promote further studies on interest, which plays an important part in the long-term calculations common in forestry, and on the productivity of forest labour. This last item touches closely on the work of the Section on Operational Efficiency, which met under its leader, Prof. U. Sundberg, of Stockholm. In this Section, the two principal subjects which were discussed were medical and physiological problems in forest work, on which much research has recently been done in Sweden, and transport in the forest in relation to the efficiency of operations.

The Section, under J. Campredon, of Paris, which is concerned with the properties and uses of timber discussed the influence of site and of provenance on the quality of the timber, and recommended further research in this field in conjunction with ecologists, geneticists and physiologists. It was also decided that fresh studies should be made of methods of sampling for the qualitative study of timber.

Immediately before the Congress, the Committee on Bibliography, a body in which the Union and the United Nations Food and Agriculture Organization are jointly concerned, met under the chairmanship of Prof. E. Saari, of Helsinki. This Committee has encouraged the use of the Oxford Decimal System of Classification for Forestry and is arranging for its translation into various languages. It is also participating in the preparation of a multilingual forest terminology, and is promoting co-operation between a large number of national and regional centres of forest bibliography; the three international centres are in Oxford, Reinbek and Washington, D.C.

Towards the end of the Congress, the senior delegate from Poland, Prof. M. Kreutzinger, of Warsaw, announced that the Polish Government had decided to offer Great Britain a breeding pair of

European bison for scientific study. The bison in Poland suffered much during the two World Wars, and it is reassuring to learn that stocks of this fine forest animal are slowly building up again. Prof. Kreutzinger stated that at present there are eighty-four bison in Poland reasonably represented by sex and by age and that the annual crop of calves is now about fourteen.

The Union elected Mr. James Macdonald, director of research and education of the Forestry Commission, Great Britain, to be president in succession to Prof. Pavari, whose term of office expires at the end of this year. Dr. van Vloten was elected vice-president. The Permanent Committee of the Union was enlarged, and now consists of the following members: Dean C. F. Korstian (Duke University, North Carolina); A. Oudin (Nancy); Prof. M. Kreutzinger (Warsaw); Dr. K. L. Aggarwal (Dehra Dun); Dr. V. L. Harper (Washington, D.C.); Prof. M. Näslund (Stockholm); Prof. A. Uzcategui (Venezuela); Prof. M. Ohmasa (Tokyo); Prof. A. Horky (Vienna); Prof. T. Bunusevac (Belgrade); and a representative, yet to be appointed, of the Institut National pour l'Étude Agronomique du Congo Belge. The Union accepted an invitation from the Government of Austria to hold its next Congress in Vienna.

After the Congress at Oxford, about a hundred and forty of the delegates took part in study tours, which lasted for a week and of which seven were conducted in different parts of Great Britain. During these tours an attempt was made to show the visitors as much as possible of the research in forestry and closely allied subjects which is proceeding at the present time in Great Britain, to inform them of the major problems still awaiting solution and to give them an impression of the variety of conditions in the woodlands and forests in the country.

J. Macdonald

SELECTION OF MANAGERS

At the annual general meeting of Unilever, Ltd., the whole of Lord Heyworth's speech was devoted to the way this organization is managed. The Unilever organization is an Anglo-Dutch partnership operating several hundred companies in more than forty different countries; a manager is one to whom is entrusted, at whatever level, the supervision or direction of others. There are altogether some 22,600 managers in Unilever, out of a total labour force of about 270,000; managers form 8 per cent of the total. Inside the general pattern the proportion of managers to the whole varies from one part of the business to another, and from one country to another.

At one end of the scale are the plantations in Nigeria and the Cameroons, where both the country and the operations are still comparatively simple. Here the managers form only about 3 per cent of the whole. In Indonesia, on the other hand, where there is a business producing both detergents and edible fats, the proportion of managers has risen to 8 per cent. In the United Kingdom, with operations in detergents, edible fats and other foods, oil-milling and toilet preparations, the proportion of managers to the total labour force reaches 11 per cent; in Holland with the same range of operations, it is about the same. In the highly sophisticated conditions of the United States, where Unilever interests embrace detergents, toilet preparations, foods and oils and fats, the managers form 15 per cent of the total of the employees. The pattern that emerges is that the higher the degree of mechanization and the more sophisticated the environment, the higher will be the ratio of managers required.

The managers fall into three main categories. At the base of the pyramid there are the junior managers, numbering about 16,400. Of these there are some 5,000 in Great Britain and 800 in Holland. This category includes the foremen and supervisors. Next comes the large class of middle and senior managers, totalling about 6,000. At the apex is the top management, the two or three hundred people who take on themselves the decisions which make or mar the success of the business as a whole. The only test applied to determine a man's suitability to enter the managerial ranks is that of merit. No particular social or educational background is demanded. An increasing proportion of prospective managers have had a university education; but Lord Heyworth forecasts that in future, as to-day, many Unilever managers will be men who came in at one of the lowest levels, who "came up the hard way" and whose qualities of leadership were developed after they had joined the business.

Selection is a matter in which decentralization is essential. In general, it is left to the individual companies and local managements throughout the world to do their own selection, whether from within their existing ranks or by recruitment from outside. They can, and do, draw upon the common fund of knowledge and experience which has been accumulated by the personnel divisions at the Company's headquarters; as a result, the technique of selection everywhere conforms more or less to a common pattern.

One basic principle is that the qualities of the potential recruit are assessed not merely by individual interview but also by seeing him perform as one of a group; he can show whether he possesses such obviously desirable qualities as intelligence, common sense, organizing ability, and the ability to get on with others. Some men are picked primarily for their specialist knowledge, and special attention is paid to developing their general management ability in the business. The man must have the germ of leadership within him, however; it seems to be more difficult at the stage of initial selection to detect this germ in the technical man than in the non-scientist. For the man reading science at the university to-day the curriculum is so specialized, and so much time has to be spent in the laboratory and lecture room that special attention may have to be paid to help him to broaden his outlook. From Unilever experience it is known that technological skill and management ability are far from incompatible.

The most important training is that which is done individually and on the job, and this must be flexible and selective. There is no general scheme of training into which everyone will fit. Training should be tailored to measure and not ready-made. Immediately, or after a short settling-in period, a man is given a job, and in that job he starts to learn the art of being a manager. This training of the men under them is a vital part of the work of all managers, and the man who neglects it or regards it as a waste of time is unlikely himself to reach the heights.

To this basic training on the job, courses provide a most valuable reinforcement, and in these post-war years this form of training has been greatly extended. Unilever courses are of two main kinds.

There is the general course, primarily designed to give a man the broad picture of industry and its economic background and to tell him something of Unilever as a whole.

The second category, the more specialized courses, are mainly devoted to teaching a particular technique such as production study, accountancy, advertising, or some technical process.

For more senior managers the opportunity may arise of going to an outside institution such as the Administrative Staff College at Henley, Nijmegen in Holland, and the advanced courses available at such places as the Harvard School of Business Administration in the United States. People are sent to all these places, sometimes to that in their own country, sometimes abroad. Then there are the courses run by universities, summer schools of business and the like, lasting three or four weeks. Industry should make a contribution, not only by ensuring that the quality of those whom it sends as students is high, but also by seconding first-class men to assist on the instructional side. If the universities are going to develop the teaching of business administration, Lord Heyworth would favour the experiment of seconding the university teacher to industry for a year or two, and so giving him an inside view of how industry works before he returns to the university to teach.

There are certain obvious advantages in possessing a corps of managers trained up in the business, professionals who at the start of their working life have made industry in general and Unilever in particular their chosen career. But there are always the dangers of inbreeding—the tendency to rest content with things as they are and to play safe, to follow precedent, to play down initiative and originality and to keep one's nose so closely to the Unilever grindstone as to let change and development in the outside world pass by unnoticed.

It may be that more interchange from one business to another at senior levels would be no bad thing. Pension rights are sometimes a difficulty, and these should not be used for fettering a man to his present job with chains of gold. In the United States, it has become the accepted pattern for a man to move upwards by switching from one business to another without suffering any stigma of disloyalty or careerism.

COURSES IN HIGHER TECHNOLOGY

THE White Paper on Technical Education which was presented to Parliament in February indicated that the annual output from advanced courses at technical colleges should be increased as soon as possible from 9,500 to 15,000 and that, as industrial techniques develop, refresher courses would be essential to provide opportunities to enable industrial personnel to keep up to date. The London and Home Counties Regional Advisory Council for Higher Technological Education hopes that, by stimulating colleges to provide special courses in branches of engineering, science, chemistry, management, production and commerce, it is making a contribution to the country's need. These are described in a recent bulletin*. The purpose of the bulletin is to give publicity to special advanced courses held in London and the surrounding counties which do not regularly appear in college calendars or prospectuses as part of a grouped course or as subjects offered for endorsement on Higher National Certificates. They are as a rule part-time (usually evening) courses; but full-time courses which are specially arranged and are not of longer than three months' duration are also included. Short courses organized by the University of London are also described in the Bulletin.

Since the issue of the first Bulletin in August 1950 many thousands of employees have attended the courses advertised. The Council forms a link between education and industry, and requests from industry for further courses on topics of interest will be gratefully received and carefully considered.

Among the courses offered are the chemistry and technology of cosmetics, analysis of power units by the use of non-dimensional plotting, microwave techniques and measurements, pulse techniques, restrictive practices and monopolies, rate processes in solids, aerofoil theory and supersonic dynamics, and electronics for biologists.

* Bulletin of Special Courses in Higher Technology, including Management Studies and Commerce, 1956–7. Part 1: Autumn Term 1956. Pp. 82. (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1956.) 1s. 6d.

EARTHQUAKES IN KERN COUNTY, CALIFORNIA, DURING 1952

IT is probable that no earthquake in history has been studied in the field by so many people as was the Arvintehachapi (magnitude 7·7) earthquake of July 21, 1952. This earthquake, one of the greatest three in Californian history, occasioned a series of aftershocks in the southern San Joaquin Valley, 220 of which, up to the end of June 1955, attained magnitude 4 or greater (Bull. 171 of the Division of Mines, Department of Natural Resources, State of California; by 36 authors and 16 Co-operating Agencies; pp. 283; November 1955). The focus of the shock was at lat. 35° 00′ ± ¾′ N., long. 119° 01′ ± 1¼′ W., depth about 15 km., and it occurred at 11h. 52m. 14·2s. ± 0·13s. The epicentre was near the eastern end of Wheeler Ridge on the Whitewolf steep reverse fault. This thrust has a strike N. 50° E. and is rather more than thirty-two miles in horizontal extent. B. Gutenberg has calculated that at the focus the fault plane has a dip of about 60°–66° towards E. 50° S. and that the slip along the fault at this depth when the earthquake happened was roughly up towards north in the upper (south-eastern) block relative to the lower (north-western) block. The vertical component of the slip was about 1·4 times that of the horizontal, the horizontal component corresponding to a relative movement north-east in the upper block and south-west in the lower block.

Surface measurements were made by triangulation by officers of the United States Coast Guard Service. Horizontal movements were small, and the Bear Mountain block moved north-east about two feet. Some fifteen miles south of Bakersfield the differences in elevation were 3–4 ft., the area to the south being uplifted and the area to the north lowered. The sharpest break was six miles south of Arvin, at Comanche Point. According to J. P. Buwalda and Pierre St. Amand, the earthquake did not develop a simple clean-cut trace along the fault, like the strike-slip ruptures on the San Andreas fault near San Francisco in 1906 and in the Imperial Valley in 1940,

or like the dip-slip scarps on the Sierra Nevada fault along the Alabama Hills in Owens Valley in 1872, or like the fault along the east side of Pleasant Valley, south of Winnemucca, Nevada, in 1915. Instead, a complex pattern of ruptures in a zone along the fault, a half-mile or more in width, was formed. The faults were sometimes made apparent by mole-track pressure ridges. According to Hugo Benioff the volume of strained rock was $7 \cdot 3 \times 10^{19}$ cm.^{3}, the average strain prior to the shock $8 \cdot 7 \times 10^{-5}$, average stress 26 kgm. cm.$^{-2}$, purely elastic strain-energy density $6 \cdot 6 \times 10^3$ ergs cm.$^{-3}$ and creep-strain energy about 5×10^3 ergs cm.$^{-3}$.

Frank Neumann and W. K. Cloud measured the maximum ground acceleration recorded on an accelerograph of the U.S. Coast Guard Survey at Taft, thirty-five miles from the area of greatest intensity, as $0 \cdot 22\,g$ for a wave of period 0·22 sec. They believe that the maximum acceleration in the central area, where the intensity on the modified Mercalli Scale was 9, may have been between $0 \cdot 35$ and $0 \cdot 5\,g$. For comparison, in the Imperial Valley earthquake of 1940, an acceleration of $0 \cdot 34\,g$ was registered at El Centro, four miles from the area of maximum intensity. A full account of structural damage and the lessons to be learned from it are given in the bulletin.

PROTEIN METABOLISM, RESPIRATION AND GROWTH

A SYNTHESIS OF RESULTS FROM THE USE OF ^{14}C-LABELLED SUBSTRATES AND TISSUE CULTURES

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THE proximate causes of growth and differentiation represent a great unsolved problem, while the mechanism of protein synthesis and the ability of units of the cell for self-duplication still defy explanation. To understand both normal and abnormal (cancerous) growth, the over-riding need is for greater knowledge of why cells grow by division and by enlargement. For the investigation of these broad problems, plant-tissue cultures are very suitable, and especially if cultures which are rapidly growing by random proliferation may be contrasted with similar cultures which merely remain in a state of rest, or relative inactivity. In the differences between the same tissue in these two states must be clues to many unsolved problems.

These conditions are well met by the use of small (3-mgm.) tissue explants from the secondary phloem of the carrot root, cut so far (1–2 mm.) from the cambium that cell division in the root has virtually ceased. Such tissue explants are exposed to a liquid nutrient medium under aseptic conditions which accurately reproduce their growth[1–4]. The more familiar nutrients, organic and inorganic, supplied in relative bulk, or at the level of requirement of the familiar vitamins, as in standard media for plant tissue cultures, permit only very slow growth by cell division or sluggish growth by cell expansion. However, when the nutrient media are supplemented by growth factors present in coconut milk (a fluid that typically nourishes an immature embryo), rapid growth by cell division ensues, leading to a proliferating mass of relatively small cells. Thus this tissue system may be placed, reversibly and at will, in the condition of comparative rest or of rapid cell division. Moreover, the induction of growth is evidently due to the stimulus of specific substances which supplement the nutrients in the basal medium. Therefore, the metabolic characteristics of growing and non-growing cells may be contrasted.

The extent of the coconut milk stimulus to cell division may be seen from the following. An initial carrot-tissue explant (about 3 mgm.) contains approximately 23–25 thousand cells. During the first three or four days of contact with the culture medium, even if this contains coconut milk, the explant tends to increase more by enlargement than by cell division; but, thereafter, the number of cells in the culture increases very rapidly, reaching approximately 200,000 in about seven days and approximately 340,000 in about twelve days. In this large number the cells so produced remain very much smaller than their counterparts in the original tissue and they are also very much smaller than the cells of similar tissue explants which remain in media unsupplemented by coconut milk and in which their rate of cell division is by comparison slow. (After twelve days in a normal basal tissue culture medium the number of cells per explant increases to about 31,000.)

The effects of the coconut milk are now attributable to certain specific substances. Some of these have been isolated from the coconut milk itself and obtained in the crystalline form, although they are not as yet fully identified (compounds *B*, *C* and *F* of Shantz and Steward[5,6]). Some, as for example compound *A* of Shantz and Steward[7], have been both isolated and identified (1,3-diphenylurea), and still others, obtained both from coconut milk and other sources such as the immature fruits of *Aesculus*, have been generally identified as belonging to a definite class of chemical substances, for example, the leucoanthocyanins[8]; and still other synthetic substances (benzthiazolyloxyacetic acid) have been found to be unexpectedly effective in stimulating cell division in this tissue system[9]. 6-Furfurylaminopurine (the substance 'kinetin' of Skoog, Miller *et al.*[9]) is

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apparently not a naturally occurring substance but is derived from nucleic acid by the action of heat, etc.; this substance causes cell division in carrot tissue in the presence of indoleacetic acid, but not nearly to the extent of coconut milk.

The present article is a résumé of work carried out on carrot-tissue explants placed, by the use of coconut milk, in the conditions of rapid growth and also, by withholding it, retained in the conditions of very slow growth. The general plan was to find the different ways in which the tissues use certain ^{14}C-labelled compounds, supplied exogenously as substrates for respiration and protein synthesis. However, quite unexpected conclusions could also be drawn, and these have a very direct bearing on the differences between fast-growing cells on one hand and the slow-growing cells on the other; they also bear upon the specific effects of the substances, natural or synthetic, that induce growth by cell division.

Experimental Design

The entire experiment was carried out on a uniform population of carrot-tissue explants from the same root. In a pre-period of seven days the explants were allowed to establish the two contrasted states desired, namely, the growing state in presence of coconut milk and the relatively non-growing state in its absence. At this point the exogenous treatments with the radioactive substrates were given, and their effects were followed over the ensuing five days, tissue samples being obtained at approximately daily intervals. In this way the effects of each substrate were determined and their time course observed. At each sampling period the following observations were made: (1) The fresh weight of the tissue explant. (2) The total amount and specific activity of the respired carbon dioxide evolved during the period. (3) The tissue was extracted with alcohol, and upon this extract subsequent chromatographic and radioautographic observations were made. (4) The alcohol-insoluble portion of the tissue was hydrolysed and the resultant extract was again subjected to subsequent chromatographic analysis. (5) The external solution was analysed to determine the change in the radioactivity which had occurred.

By the application of paper chromatographic methods combined with appropriate procedures of radioautography, the following determinations were made: (1) All the identifiable nitrogen compounds present in both the alcohol-soluble extract and the acid hydrolysate of the alcohol-insoluble material were determined quantitatively. This was done using a phenol/collidine–lutidine system. For each of these constituents, eluted from the paper, the total radioactivity was determined, and the specific activity was calculated. (2) A similar procedure on the same chromatogram was applied to the sugars, fructose being determined separately, glucose and sucrose combined as one sample.

Combining the data from the growth of the tissue cultures and the analytical data, one can calculate the *total amounts* of each constituent present in a tissue explant at a given time and thus determine the absolute changes which occurred with time as a consequence of the experimental treatments. The radioactive substrates supplied singly in trace amounts to the media of both growing and non-growing tissue were as follows: (1) ^{14}C-uniformly labelled glucose obtained biosynthetically from tobacco leaves by Dr. P. V. Vittorio, of Queen's University, Kingston. (2) Uniformly labelled ^{14}C-glutamine obtained biosynthetically from Swiss chard leaves by one of us (R. G. S. B.). (3) Uniformly labelled ^{14}C-γ-aminobutyric acid obtained from the glutamine by use of a suitable decarboxylase preparation, this conversion being carried out by one of us (E. W. Y.).

In the choice of these substrates the ideas were as follows. The use of ^{14}C-labelled sugar was expected to show the extent of the direct use being made of glucose in the processes of respiration leading to evolution of carbon dioxide and also the ease with which this sugar enters into other concomitant metabolic reactions, such as those of protein synthesis. Glutamine looms large in all modern ideas of plant nitrogen metabolism and it was regarded as a most likely point of departure for protein synthesis: by the use of ^{14}C-labelled compound it was expected that this could be traced. Since its discovery, γ-aminobutyric acid has been regarded as a possible decarboxylation product of glutamic acid[10]. The experiment offered the opportunity to test whether the γ-aminobutyric acid merely acted as an alternative source, by carboxylation, of glutamic acid, or indeed, whether the tissue could utilize this substrate at all.

Role of γ-Aminobutyric Acid in Relation to Glutamine

γ-Aminobutyric acid in higher plants has been thought to arise by decarboxylation from glutamic acid[10]. However, the radioautographs and the specific activity data, etc., show very clearly that when γ-aminobutyric acid is supplied to the tissue it passes readily to glutamic acid and glutamine and then into other nitrogenous substances. On the other hand, when ^{14}C-glutamine is supplied the conversion to γ-aminobutyric acid is slight and even negligible after 100 hr. One must therefore regard γ-aminobutyric acid, now known to be of very frequent occurrence free in plants, not merely as a waste or decarboxylation product of glutamic acid, but rather as a substance which is en route to glutamic acid and glutamine. Whatever the method of its use or synthesis, γ-aminobutyric acid is now to be regarded as an important metabolite capable of donating both carbon and nitrogen in the active metabolism of growing and non-growing plant cells[11].

For purposes of the comparisons required, the basis to which the analytical data were calculated was the individual tissue explant. Proceeding in this way the *total amount* of each metabolite present in a single culture was recorded, or calculated, so that the absolute changes of these substances with time could be determined. Owing to the rigorous control achieved under the experimental conditions it was possible to carry out all these various processes with gratifying accuracy.

Specific Activity of Tissue Metabolites and its Interpretation

When first recorded, the total radioactivity present in a given substance in the tissue was represented not merely in the units 'total counts per minute' but as the equivalent weight (μgm.) of carbon with the same activity as that of the source: the specific activity of the carbon in the compound therefore becomes the percentage of the carbon present in the compound which had the same activity as the source. Thus the specific activities of the compounds present in the tissue are always represented by percentages

of the specific activity of the source supplied. However, it became evident that it was possible for a compound in the tissue to have a specific activity *greater* than the metabolite within the tissue from which it must have been derived. Re-evaluating this situation, we became impressed by the following facts.

Since the cell is a heterogeneous system, it is entirely possible for two immiscible metabolic pools to co-exist and to contain the same substrate, which may be subject to different reactions or to similar reactions proceeding at different rates. Thus, it may arise that a given compound may be subject in a given time to increase from one source and decrease from another; that is, there may be both entry and withdrawal from the total complement of this substance in the cell. Thus, carbon of high specific activity may be entering the substrate in question in one cellular phase, while carbon of low, or zero, activity is either entering or leaving that same substance in another phase. Since on analysis the two phases become mingled, the average specific activity of the compound in the cell as a whole may bear no direct relationship to its place in a metabolic sequence of events.

To clarify such situations, the additional information that is required is the *specific activity* of the carbon which is in transit *to and from the metabolite in question*. In order to obtain this, the following data were necessary: (1) the change in a given period in the total carbon contained in the metabolite in question; (2) the change in the same period in the activity contained in the metabolite in question.

From this, by dividing (2) by (1), the specific activity of the carbon *in transit* may be determined. Thus, throughout the investigation it was found necessary to record changes in the metabolites in the following way: (1) the change in the total carbon present in the metabolite (Δ total C); (2) the change in total activity, recorded by its equivalent of carbon (Δ C $\equiv$ activity); (3) the specific activity of the carbon appearing in, or disappearing from, the pool of the substance in question, recorded as a percentage of the specific activity of the carbon in question

$$\left(\frac{\Delta \text{ C} \equiv \text{activity}}{\Delta \text{ total carbon}} \times 100\right)$$

The utility of this form of analysis may be illustrated by some of the results obtained with reference to glutamine and glutamic acid; these are summarized in Table 1.

From Table 1, it is not surprising that the glutamic acid actually present in the tissue achieved during the period had nearly the same activity as the carbon source which was supplied. It is more surprising, however, that the glutamic acid derived from glutamine actually had higher specific activity than the glutamine contained in the tissue. This obviously means that there is a non-radioactive pool of glutamine in the tissue; but the other conclusion which follows is that the glutamic acid in the tissue must have been derived from the active pool of glutamine, not from the inactive pool. Thus the two pools of glutamine must have been separated in the cell. From the last column in Table 1, it is apparent that two-thirds of the carbon involved in the *change* in glutamine content of the tissue came from an active source and one-third from an inactive source, whereas the corresponding figure for glutamic acid is obviously anomalous. The carbon involved in the metabolic change of glutamic acid during the period apparently came from a source which had a specific activity more than twice that of the ultimate source of the activity in question. The anomaly referred to in connexion with glutamic acid is but one of several types of anomalous result that are encountered under this mode of procedure. Such anomalies are of the following kinds in which the metabolic change may seem to have been mediated by (1) carbon far richer in activity than its actual source, (2) carbon far less active than that actually supplied, (3) by carbon of an infinitely high activity, or (4) by carbon of an activity that appears to be arithmetically negative. Obvious explanations which cover these various type situations are:

Table 1. Free Glutamic Acid and Glutamine in the Fast-growing Carrot Tissue supplied with ^{14}C-glutamine during Period 1 (0 to 22 hr.)

Tissue metabolite	Specific activity of C*	Δ Total C†	Δ C $\equiv$ Act.‡	$\frac{\Delta \text{ C} \equiv \text{Act.}}{\Delta \text{ Total C}} \times 100$§
Glutamine	66	261	175	67
Glutamic acid	99	19	44·3	233

* As per cent of specific activity of the carbon in the supplied glutamine.
† Change in μgm. of carbon in the metabolite present in 10 explants.
‡ Change in μgm. of carbon of the same activity as the source to account for the change in total activity in the metabolite.
§ The apparent specific activity, as a percentage of that of the source, of the carbon in transit to the metabolite.

(1) This refers to a situation in which there is concurrent disappearance of the inactive compound from one cellular phase while it is increasing in the radioactive form in another. This leads to the apparent use of carbon of a specific activity higher than the source.

(2) In this situation the specific activity appears to be less than that of the source: this could arise either by dilution of the active compound by the inactive metabolite, or else by the concurrent appearance of the inactive compound synthesized in one phase while it is increasing in the radioactive form in another.

(3) Here the carbon involved in the reaction appears to have been of infinitely high activity: this must imply that there is no net change in the metabolite in the cell as a whole, although there has been synthesis of the radioactive compound in one phase with concurrent disappearance of its inactive form from another phase.

(4) This situation is one in which the carbon involved in the metabolic reaction during the period appears to have negative activity. This anomaly results when there is a decrease in the metabolite in the cell as a whole, during a period in which some radioactive synthesis occurred, or again by a greater increase of the inactive compound in the cell than there is decrease of the radioactive compound in the cell.

While there is nothing intrinsically new in these ideas, the merit of this method of formulation is that the unusual and anomalous events become immediately obvious so that they can be subjected to further analysis and interpretation. In one way or another, all the type situations indicated above were encountered in the experiments in question, and this compels the interpretation of the data in ways which take account of the separation of the metabolites in different phases in the cell and the existence, in these phases, of concurrent and different reactions.

Interpretation of the Respiring, Synthesizing Cell in Terms of Separate Phases or Compartments

The entire body of data may be comprehended in terms of the scheme which is illustrated in Fig. 1.

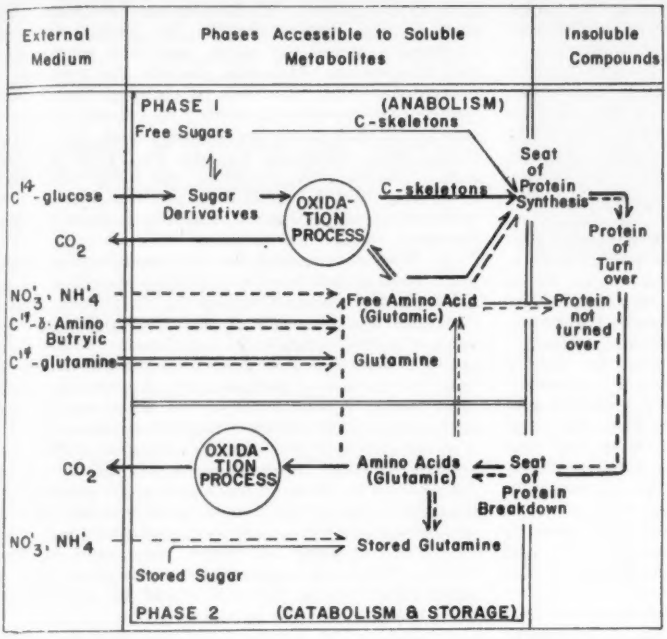

Fig. 1. Diagram to illustrate the main metabolic pathways in cultured carrot tissue explants

Comment on this scheme will be in two parts: first, the novel features will be stressed; and second, sufficient data will be given to indicate how it rests on experimental evidence.

(1) An important, though certainly not new, feature of the scheme is the idea that protein participates in respiration and contributes to the carbon dioxide. This idea, probably first stressed by Gregory and Sen[12], has also been used for explaining certain characteristics of tissue slices[13,14].

(2) The scheme is based upon the recognition that the cellular organization provides for different phases in which compounds may exist without equilibration and may participate in distinct metabolic reactions. In phase 1 the emphasis is on anabolism and protein synthesis; in phase 2 the emphasis is on catabolism, protein breakdown and storage. In both these phases oxidation processes are conceived to occur with the ultimate formation of carbon dioxide. The oxidation processes in both phases may well involve the same enzymatic systems, the distinctive feature of phases 1 and 2 being rather the accessibility of the enzymes to the products of protein breakdown on one hand (No. 2) or to the seat of protein synthesis on the other (No. 1). At this stage no attempt is made to identify the phases with known morphological features, or even to recognize a degree of geographical separation beyond that which is imposed by selective accessibility of particular substrates to the enzymes in question. In other words, there are areas within the cell which are specialized for these particular metabolic functions.

(3) The scheme recognizes that amino-acids and amides, when they are supplied exogenously, or arise from protein breakdown, are separated in the cell, and active protein synthesis is thus relatively independent of the pool of free amino-acids and amides. In these circumstances, protein synthesis is not visualized as the mere condensation of the *free* amino-acids; but carbon skeletons, largely derived from sugar, condense with nitrogenous groups (for example, from glutamine and glutamic acid), and these are embodied in the protein molecule at the seat of synthesis. If amino-acids are intermediates in this synthesis, then these molecules may not occur free and they do not permeate the cell as a whole.

(4) The scheme also recognizes that continuous turnover of proteins takes place, but that different moieties of the cell proteins may participate therein to a different degree. It is the pace of protein turnover that determines, by supplying nitrogen-free residues, the rate of carbon dioxide evolution by this pathway (phase 2).

The main lines of experimental evidence which led to the formulation of Fig. 1 are summarized below and illustrated by some representative data shown in Tables 2 and 3.

(1) The scheme depends first upon the fact that separate metabolic phases exist in the cell. This

Table 2. Specific Activity of the Carbon in the Combined Amino-acids derived from various ^{14}C-labelled Substrates. Period 5 (109 hr.)

Amino-acid in protein	^{14}C-labelled substrates supplied		
	^{14}C-glucose	^{14}C-glutamine	^{14}C-γ-aminobutyric
Glutamic acid	46	28	8·5
Aspartic acid	43	22	10·2
Alanine	50	2·5	—

Table 3. Specific Activity of the Carbon in the Respired Carbon Dioxide and in the Combined Amino-acids derived from ^{14}C-labelled Compounds

Period 2 (22–40 hr.). Periods 4 and 5 (61–109 hr.)

^{14}C substrate	Specific activity in sugar in tissue		Specific activity of combined glutamic acid		Specific activity of respired carbon dioxide	
	Period 2	Period 4–5	Period 2	Period 4–5	Period 2	Period 4–5
Glucose—rapidly growing tissue	40–55	71	N.D.	46	46	74
Glucose—slowly growing tissue	26–29	48	low	46	34	76
Glutamine	0	1·4	22	28	18·4	24·6
γ-Aminobutyric	0	1·1	2·3	8·5	7·7	14·1

conclusion follows from the type of evidence presented in Table 1, of which a salient example is as follows: The specific activity data require that there is a source of storage glutamine which is distinct from, and does not mingle with, the glutamine that passes via glutamic acid and other amino-acids into the protein. The specific activity of glutamic acid in the tissue is found to be higher than that of glutamine, which is compatible with a source of inactive glutamine in the cell. Also, the specific activity of the free glutamic acid is approximately that of its source and it is found to remain consistently high throughout the course of the experiment. Therefore, if there is any other glutamic acid that arises during the course of metabolism this must occur elsewhere, for it cannot mingle with the radioactive glutamic acid that is incorporated into the protein; moreover, any such inactive glutamic acid must be rapidly converted to some other form, for example, glutamine.

Since the production of radioactive glutamic acid from the ^{14}C-glutamine supplied has been identified with protein synthesis in phase 1, then the production of inactive glutamine after protein breakdown, which, as indicated, must take place in a separate phase, is therefore identified with phase 2. By the same token, any glutamic acid that arises by protein breakdown also appears in phase 2, and protein breakdown, in contrast to synthesis, is also identified with phase 2.

(2) The specific activity of the free amino-acids in the tissue is not related to the activity of the amino-acids in the protein. Without giving the detail, the specific activities of the amino-acids which acquire ^{14}C-label in the protein tend to be about the same, whereas the specific activity of the free amino-acids vary from one compound to another. The results also show that ^{14}C-glucose was more effective in labelling the protein amino-acids even than such ^{14}C-labelled nitrogen compounds as glutamine and γ-aminobutyric acid. In fact, ^{14}C-labelled glucose actually labelled glutamic acid in the protein more effectively than did ^{14}C-labelled glutamine, which gave rise directly to glutamic acid (see Table 2). Therefore, this is the sort of evidence which leads in Fig. 1 to the suggested use of carbon skeletons, mainly derived from sugar, as the chief source of carbon in the protein synthesized. Furthermore, this feature emphasizes that the anabolic metabolism of glucose to protein is mainly associated with phase 1.

(3) Fig. 1 is also built on the presumption that protein turnover must take place. This conclusion follows because the amount of radioactivity incorporated into certain protein amino-acids, with due regard to the amount of protein synthesized and the specific activity of the carbon source, could not be accounted for apart from alternating protein breakdown and re-synthesis. This point will be discussed later.

(4) The specific activity of the carbon in the evolved carbon dioxide tends to run parallel to the specific activity of the carbon in the protein; but it does not vary directly as the activity of the carbon in sugar; this is especially true of tissue treated with ^{14}C-glutamine and ^{14}C-γ-aminobutyric acid. When the tissue was treated with ^{14}C-labelled glucose, there was a tendency for the specific activity of the carbon in the carbon dioxide to reflect that in the sugar, but in fact it often exceeded this, especially in the later periods of the experiment; but here again the specific activity of carbon in the carbon dioxide reflected that in the protein. All this evidence indicates that part of the carbon dioxide be derived from an alternative source to sugar, and this source may well be protein. However, despite the evidence of protein turnover, there was no conspicuous accumulation of the freed amino-acids; specifically, glutamic acid could not have accumulated (see (1) above), though some glutamine did arise from protein breakdown. Presumably, therefore, the amino-acids that arise from protein breakdown are freely utilized as to their carbon in respiration and as to their nitrogen for re-synthesis of protein.

(5) Whereas some of the amino-acids which arise from protein breakdown might be regarded as re-available for protein synthesis by drift from phase 2 to phase 1, the results require that this could not have occurred appreciably for glutamic acid. Since the conclusions with respect to protein turnover are based on results of radioactivity, this transfer might have occurred with some of the amino-acids which never acquired ^{14}C-label during the experiment; but it could not have occurred to any great extent with respect to those amino-acids which did become so labelled. Also, some of the inactive glutamine which accumulated in phase 2 could have been derived from exogenous sources of nitrogen and from non-radioactive stored sugar. However, this could not have occurred from the sugars present in phase 1 to an appreciable extent, for this would be incompatible with the specific activity data.

(6) When the formation of metabolically active protein is accentuated during growth its synthesis is intimately related to the stimulus to respiratory activity. This will be discussed below.

(To be continued)

[1] The presence of Prof. E. W. Yemm, of the University of Bristol, England, as a Visiting Rockefeller Fellow in the Department of Botany at Cornell University provided the occasion for a re-investigation of the use of glutamine and γ-aminobutyric acid by plants and especially by carrot tissue cultures. The facilities for the experiments employing tissue cultures, with and without coconut milk, under the standardized conditions which are required were already well established in this Department and, with the assistance of Miss K. Mears, these facilities were being used in a variety of investigations supported by the National Cancer Institute of the U.S. Department of Health, Education and Welfare. At the planning stage the role of glutamine had been discussed by one of us (F. C. S.) with Prof. G. Krotkov, of the Department of Biology, Queen's University, Kingston, Ontario, and to his interest in the problem we owe the supply of the ^{14}C-labelled substrates which were used. One of us (R. G. S. B.) from the laboratory at Queen's University undertook the responsibility for the radioactive measurements, leading to the specific activity determinations of the various metabolites studied. The necessary chromatographic separations and the use of quantitative paper chromatography and radioautography were carried out in the Department of Botany at Cornell University, and in this work we wish to acknowledge the help of Dr. J. K. Pollard, Mr. David Margolis and Mrs. Greenwood, all working with one of us (F. C. S.).

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Interactions of Ribonucleotide Polymers with Tobacco Mosaic Virus Protein to form Virus-like Particles

THE purified protein and ribonucleic acid constituents of tobacco mosaic virus can be combined *in vitro* to form infectious nucleoprotein rods which resemble the original virus in size and shape and which have their nucleic acid surrounded by protein as in the virus[1]. Although the viral nucleic acid is necessary for infectivity, the formation of rods seems to depend on an inherent property of the viral protein; the latter can be aggregated in the absence of nucleic acid to form cylindrical tubes which superficially resemble the virus[2] but possess no infectivity. When the viral nucleic acid is present, it occupies a region within the tube and apparently serves to 'cement' the protein sub-units together, since the nucleoprotein particles are stable at *p*H values higher than those at which the protein tubes disintegrate[3]. This cementing function might be thought to depend on some property specific to the nucleic acid of tobacco mosaic virus. In order to investigate such a possibility, we have studied the interactions of the viral protein with several widely differing artificial and natural ribonucleotide polymers.

The artificial polymers were gifts from Dr. S. Ochoa and had been prepared by the action of *Azotobacter vinelandii* polynucleotide phosphorylase on various nucleoside diphosphates[3]. They comprised four single-nucleotide polymers containing, respectively, adenylic, cytidylic, uridylic and inosinic acids; and two 'mixed' polymers: adenylic-uridylic acid polymer and a polymer containing the four nucleotides adenylic, guanylic, uridylic and cytidylic acids. From chemical end-group determinations[4], the approximate mean numbers of nucleotide residues per chain have been found to be: adenylic-polymer, 270 residues; adenylic-uridylic-polymer, 120 residues; and adenylic, guanylic, uridylic, cytidylic-polymer, 30 residues.

Two preparations of yeast ribonucleic acid were also tested. One sample, having a molecular weight of the order of 10^5, was a gift from Dr. F. Worthington Allen[5]. The other yeast nucleic acid was prepared by dialysing a commercial sodium nucleate (Schwartz Laboratories, Inc.) against distilled water and collecting the material which passed through the dialysis tubing. A nucleic acid prepared in this way would be expected to consist of chains of the order of five residues in length[6].

The following mononucleotides were also tested as controls: (1) adenosine 5′ diphosphate; and (2) a mixture of the three adenosine monophosphates (2′-, 3′- and 5′-) prepared by mixing 3 parts yeast adenylic acid with 2 parts adenosine 5′ phosphate.

In the reaction mixtures, a solution containing 2 mgm./ml. tobacco mosaic virus protein (prepared by Dr. H. Fraenkel-Conrat[1]) and about 1 mgm./ml. nucleic acid or mononucleotide was brought to 0·03 *M* in acetate by the addition of 3 *M* acetate buffer at *p*H 6. The mixtures were allowed to stand overnight at about 5° and were then dialysed two or more times against distilled water which had been adjusted to *p*H 7·6 ± 0·2 by the addition of sodium hydroxide. Finally, they were centrifuged for 45 min. in a field of $10^5 g$ and the pellets were resuspended in 'Pyrex'-distilled water for examination with the electron microscope.

Fig. 1. Nucleoprotein rods made with tobacco mosaic virus protein and a high-molecular weight polymer of uridylic acid. The rods are of the same apparent width as tobacco mosaic virus particles. Included for size comparison is a spherical particle of polystyrene latex having a diameter (260 mμ) nearly equal to the length (300 mμ) of the normal virus particles. × 25,000

All preparations containing any of the nucleotide polymers were found to be aggregated into rods of the same apparent width as tobacco mosaic virus but of various lengths (Fig. 1). The distributions of rod-length appear, from preliminary observations, to be much the same for all the polymers and to be therefore independent of the molecular weight and composition of the ribonucleic acid. The protein without nucleic acid could be made to form similar rods by lowering the *p*H to 6, but all such controls became disaggregated during the dialysis and yielded relatively small centrifugal pellets consisting of disk-shaped particles with central holes[7]. Likewise, the preparations containing mononucleotides failed to yield rods in the pellets.

Ultra-violet absorption measurements of the resuspended pellets indicated that the rods consisted of nucleoproteins resembling tobacco mosaic virus in nucleic acid content. After clarifying several of the resuspensions with alkali (0·01 *M* sodium hydroxide in the presence of 0·06 per cent sodium dodecyl sulphonate), diluting and neutralizing, absorption spectra were obtained which could be graphically resolved into the spectra of the separate protein and nucleic acid components. (Appropriate component spectra were obtained from solutions of the protein and nucleic acids which had been subjected to the same clarification treatments as those used with the nucleoproteins.) These analyses were done for the adenylic- and uridylic-polymer nucleoproteins and for the nucleoprotein made with the high-molecular weight yeast nucleic acid. In each case, the nucleic acid appeared to constitute about 4 per cent of the mass. Direct phosphorus and nitrogen determinations on one sample of adenylic-polymer nucleoprotein indicated a nucleic acid content of approximately 6 per cent. The nucleoproteins further resembled tobacco mosaic virus in that incubation with ribonuclease caused no appreciable hydrolysis of the nucleic acid component.

Several of the pellets, resuspended in equal volumes of water, were rubbed on the leaves of various plants to test their ability to produce disease symptoms. The nucleoprotein inocula contained about 0·5 mgm. protein per ml. Those containing adenylic-polymer and adenylic, guanylic, uridylic, cytidylic-polymer

were compared with the resuspended pellet from the protein control on opposite half-leaves of *Nicotiana glutinosa* and a variety of *N. tabacum* containing the *N. glutinosa* gene for the production of local lesions (Holmes[8]). None of the preparations gave local lesions on *N. glutinosa*. On the Holmes variety the mean numbers of tobacco mosaic virus lesions per half-leaf were; protein alone, 0·28; protein plus adenylic-polymer, 0·25; protein plus adenylic, guanylic, uridylic, cytidylic-polymer, 0·05. The lesions can be accounted for by a very small virus contamination in the viral protein preparation. (Comparable numbers of lesions are produced by inocula containing tobacco mosaic virus at a mass concentration 10^{-6} times that of the nucleoprotein solutions used here.) No symptoms were produced on *N. tabacum*, var. Turkish, *N. sylvestris*, *Lycopersicum esculentum* or *Datura meteloides*. Preparations containing cytidylic-, inosinic- and uridylic-polymers were tested only on the Holmes variety and also gave no more lesions than could be accounted for by the virus contamination in the protein.

The failure of these nucleoprotein particles to cause disease symptoms is consistent with the current idea that the biological action of a nucleic acid depends on the exact arrangement of its nucleotide residues. The present results indicate, however, that this arrangement may have little to do with the ability of a ribonucleic acid to form stable, organized complexes with protein. In view of the great diversity in the length and composition of the polymers tested, one might conclude that any ribonucleic acid (but not a mononucleotide) would interact with tobacco mosaic virus protein in the same way.

We are grateful for the advice and help of Prof. Robley C. Williams.

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Solubilization of Water-insoluble Mucopolysaccharides and a New Method for the Preparation of Blood-Group Substances

Studies of native secretions or tissue extracts which contain mucopolysaccharides are frequently difficult because, after isolation and partial purification, a considerable part of the mucopolysaccharide in the original material has become insoluble in water or saline.

This particular change in solubility occurs during the recovery from human and animal tissues and secretions of mucopolysaccharides which possess specific serological properties characteristic of the ABO and 'Lewis' blood group systems. These materials have been most frequently isolated by extracting dried native cyst fluids or tissue extracts with 90 per cent liquid phenol[1], whereas tissues are subjected to peptic hydrolysis to release the specific substances before extraction with phenol[2]. Blood-group materials from either source are mostly found to be insoluble in 90 per cent phenol; but if soluble, as they sometimes are after treatment with pepsin, they are readily precipitated from this solvent with low concentrations of ethanol. The accompanying proteins are soluble in 90 per cent phenol and are readily eliminated.

It is found, however, that group-specific mucopolysaccharides prepared in this way frequently yield material which is only partly soluble in water or saline. Sometimes the water-insoluble moiety constitutes the major part of the substance obtained and in consequence the method of isolation must be considered unsatisfactory. Paramucin, a material of considerable interest as a source of human blood-group substance, occurs naturally as a water-insoluble gel; it is the 'trembling jelly' type of mucin first described by Mitjukoff[3]. Large amounts occur in certain ovarian cysts; but it cannot be brought into solution until partially hydrolysed with acid or alkali, procedures which must be avoided if the original immunological properties of the material are to be preserved. Similarly, serological investigations of human saliva for purposes of certain genetical studies[4] must be made on the whole of the serologically reactive components in the native secretions, and the results must be considered unsatisfactory if only part of the specific mucopolysaccharide complexes contained in the test fluid are soluble in saline and thus available for examination. Water-insoluble forms of the mucopolysaccharides are frequently produced during purification, storage at low temperature and by heat treatment to remove free protein, to inactivate enzymes or to maintain sterility.

It is known that water-insoluble materials of this kind can sometimes be solubilized in strong solutions of urea or certain inorganic salts, like potassium thiocyanate; but in our experience removal of the peptizing agent by dialysis usually results in the recovery of a material which has no greater solubility in water or saline than the starting substance.

It has now been found that these different kinds of water-insoluble mucopolysaccharides can be rendered soluble in water by treatment with ficin, an enzyme preparation from fig latex. When the water-insoluble materials are treated in buffer at *p*H 7 with 0·1–1 per cent by weight of purified ficin, activated with potassium cyanide or cysteine and versene, they dissolve rapidly to yield clear, viscous solutions which retain their blood-group specific characters unimpaired. Group substances obtained after ficin treatment of the water-insoluble materials derived from pseudomucinous ovarian cysts possess the same composition and group-specific serological properties as do substances which are insoluble in phenol and soluble in water obtained from the same cyst material by the usual technique[5]. Prolonged (48 hr.) treatment of purified group substances, isolated without the use of ficin, with large amounts (5–10 per cent w/w) of purified ficin yield materials which show no obvious change in chemical composition or destruction of their original (ABO) group specificity. However, the solubility of the resulting materials in 90 per cent

phenol, their lower viscosity and their behaviour in the ultracentrifuge, reveal that the preparations are more polydisperse and have a smaller average molecular size, although remaining electrophoretically homogeneous at *p*H 8. The physical properties of these materials are being studied with our colleague, Dr. R. A. Kekwick, and the underlying process which brings about solubilization of the water-insoluble mucopolysaccharide materials is being further investigated. The lysozyme component of the commercial ficin does not bring about the solubilization of the substances studied.

An alternative procedure which does not involve the use of phenol for the isolation of the specific blood-group substances is long overdue as, with one exception[5], almost all the group-specific mucopolysaccharides described in the literature which have been thoroughly examined by chemical, physical and immunochemical methods have been treated with phenol at some stage in their preparation[6]. The stability of the group substances on treatment with ficin and the powerful proteolytic activity of this enzyme preparation on many proteins prompted us to examine the possibility of using ficin as a means of removing the non-specific protein in native cyst fluids and saliva, and thus allow the specific substance to be recovered from them by dialysis and simple fractionation from aqueous solution by inorganic salts or organic solvents. By the use of ficin it is possible to carry out rapidly at *p*H 7 the isolation of the group-specific materials from tissues and secretions, and the resulting serologically active mucopolysaccharides recovered have the same qualitative composition as, and similar analytical figures to, the materials isolated by the usual phenol-extraction technique. Occasionally cyst fluids have yielded active group materials which possess higher nitrogen values (10–11 per cent) and lower fucose contents (6–7 per cent) than those obtained by the phenol method. Full details of the solubilization of water-insoluble mucopolysaccharides and the alternative method for the preparation of group-specific substances will be given elsewhere.

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Independent Requirements for 'Crithidia Factor' and Folic Acid in a Trypanosomid Flagellate

THE trypanosomid parasite of mosquitoes, *Crithidia fasciculata Anopheles* strain (*ATCC* 11745), when grown in a defined medium[1], required for growth unusually high levels of folic acid. In the presence of 'crithidia factor' (an unconjugated pteridine), much lower concentrations of folic acid supported growth; indeed, at times a separate folic acid requirement was not demonstrable[2,3]. Our collaborators at the American Cyanamid Co. have identified the crithidia factor in human urine as 2 : NH_2,4 : OH,6-dihydroxypropyl pteridine[3]. In our experiments reported here, both the 6-dihydroxypropyl and a partially purified sample of the 6-trihydroxypropyl pteridine (generously supplied by Dr. E. L. Patterson) were used.

Table 1. BYPASS OF FOLIC ACID BY THYMINE FOR THE GROWTH OF *Crithidia fasciculata*

Additions	2 : NH_2,4 : OH,6-trihydroxypropyl pteridine* (mμgm./ml.) None	0·1	1·0	100·0
None	0·04†	0·06	0·08	0·12
Folic acid 0·3 mμgm./ml.	0·04	0·05	0·04	0·60
,, 1·0 ,,	0·04	0·16	0·56	0·80
,, 3·0 ,,	0·04	0·80	1·00	0·93
,, 30·0 ,,	0·04	—	—	—
,, 0·1 μgm./ml.	0·42	—	—	—
,, 0·3 ,,	0·78	—	—	—
,, 0·6 ,,	0·90	—	—	—
,, 1·0 ,,	1·00	—	—	—
Thymine 10·0 μgm./ml.	0·04	0·34	0·79	—
,, 30·0 ,,	0·04	0·78	1·02	—

* A 20-fold lower concentration of 2 : NH_2,4 : OH,6-dihydroxypropyl pteridine could, for each value, be substituted for the trihydroxypropyl derivative.
† Growth expressed as optical density.

By methods previously described[1,2], and with the use of the two pteridines, we have shown that (*a*) both folic acid and crithidia factor are required for growth of *C. fasciculata*; and (*b*) when folic acid is bypassed by supplying thymine, preformed crithidia factor is indispensable (Table 1). Folic acid, when it is the sole source of pteridines, then functions in its usual role in 1-carbon metabolism and is a precursor of a class of pteridines which has an independent function.

There are indications of connexions between riboflavin and pteridine-containing vitamins: (*a*) it has been suggested that *Eremothecium ashbyii* may accumulate a pteridine[4]; (*b*) grasshopper eggs produce a pteridine which replaces riboflavin for the growth of several lactobacilli; the riboflavin content of the eggs decreases as the pteridine content increases[5]. Results with *C. fasciculata* show that while high levels of riboflavin are required when folic acid is the sole source of crithidia factor, in the presence of preformed crithidia factor plus low concentrations of folic acid, riboflavin is spared (Table 2); these results account for the earlier observation[6] that thymine in the presence of high levels of folic acid (when folic acid is the sole source of pteridines) spares riboflavin. Folic acid was not spared by thymine. This may mean that the cleavage of folic acid to yield unconjugated pteridines was not enhanced by thymine.

The wide distribution of crithidia factor in Nature—it is contained in yeast[2], *Drosophila* eyes[7], liver[2,6] and human urine[3]—invites speculation on the

Table 2. SPARING OF RIBOFLAVIN BY CRITHIDIA FACTOR

Additions	Riboflavin (mμgm./ml.) None	10·0	100·0
None	0·04	0·05	0·08
Folic acid 30·0 mμgm./ml.	0·04	0·09	0·09
,, 100·0 ,,	0·04	0·24	0·61
,, 300·0 ,,	0·04	0·47	0·89
,, 1·0 μgm./ml.	0·04	0·76	1·18
Thymine 30·0 ,,	0·04	0·05	0·12
Pteridine* 10·0 mμgm./ml.	0·03	0·12	0·26
Pteridine 10·0 ,, plus folic acid 6·0 ,,	0·03	0·97	1·24

* 2 : NH_2,4 : OH,6-trihydroxypropyl pteridine was used in this experiment.

occurrence of growth-factor requirements in other organisms which are satisfied by unconjugated pteridines.

It is not known whether in higher animals folic acid satisfies a multiple requirement. Might such a requirement comprise, besides folic acid itself, a requirement for a pteridine of the crithidia-factor type ?

An enzyme in coliform bacteria cleaves folic acid and its analogues to simple pteridines[6]. The observation that mammalian liver is rich in crithidia factor raises the question of the source of unconjugated pteridine in animals : Does it originate by cleavage of folic acid in the gut or elsewhere, or does it have some other dietary precursor ?

Fig. 1 shows a scheme for the biosynthetic interrelationship among folic acid, riboflavin and crithidia factor. 'Compound *X*' represents the intermediate(s) connecting riboflavin and folic acid pathways.

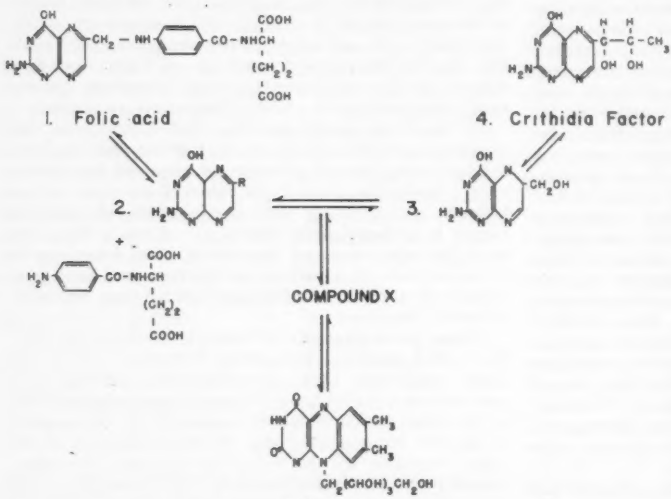

Fig. 1. Proposed scheme of interrelationships of folic acid, riboflavin and crithidia factor. Compound 3 has some crithidia factor activity

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Erythrocytin : an Inhibitor of 8-Hydroxyquinoline ('Oxine') derived from Erythrocytes

8-Hydroxyquinoline ('oxine'), a powerful antibacterial *in vitro*, and 7-allyl-3-aza-oxine are reported to be without chemotherapeutic effect in mice[1]. Their *in vitro* bacteriostatic effects were considerably reduced in the presence of intact, but not of lysed, mammalian erythrocytes[1]. We have now investigated this *in vitro* inactivation of oxine to determine whether it is caused by uptake of the drug by erythrocytes, chemical transformation, or by the liberation of an oxine-inhibiting substance.

Solutions of oxine in normal saline at *p*H 7·3 were found to lose their antibacterial effect if incubated with washed erythrocytes of many mammalian species, although nearly all the added oxine was shown to be still present in the solutions. A typical experiment using washed rat erythrocytes is described below.

To a solution of oxine (10 ml. containing 0·1 mgm./ml.) in normal saline free from heavy metals at *p*H 7·3 was added 1 ml. of normal saline free from heavy metals containing 4,000 million washed rat erythrocytes and the system incubated for 1 hr. at 37° C. The cells were then separated by centrifuging. The supernatant was devoid of bactericidal activity, and dilutions (1 in 20) in distilled water, in 0·01 *N* sodium hydroxide, and in distilled water containing an equimolar proportion of ferrous ammonium sulphate were found to exhibit ultra-violet absorption spectra identical with those shown by solutions of oxine under comparable conditions. The spectra indicated that only about 15 per cent of the added oxine had been removed by the erythrocytes, and the rest was unchanged and capable of co-ordination with ferrous ions in a normal manner.

Extraction of the supernatant with chloroform yielded a solid possessing the normal antibacterial activity of oxine and which, as a solid mull in 'Nujol', gave an infra-red spectrum identical with that given by oxine. The remaining aqueous solution was aerated overnight to remove the dissolved chloroform. Solutions prepared by dissolving oxine in this liquid were devoid of antibacterial action ; however, heating at 100° C. for 2 min. followed by the addition of oxine yielded solutions with normal antibacterial properties.

Incubation of erythrocytes with normal saline as reported above, but in the absence of oxine, gave supernatants which did not inactivate oxine. Saline solutions of oxine were not inactivated upon incubation with lysed erythrocytes or with washed leucocytes.

The results demonstrate that the inactivation of oxine by erythrocytes is due to the liberation (or production) upon incubation of the cells in presence of the drug of a thermolabile inhibitor which we propose calling 'erythrocytin'. The apparently normal metal-chelating properties of the 'inactivated solutions' are of interest, because it has been suggested that oxine

owes its antibacterial action to its ability to penetrate the bacteria as a 2 : 1 complex with iron (or copper) and exert its toxic effects as the 1 : 1 complex[2]. It is possible that erythrocytin might be effective in blocking the penetration of the oxine-iron complex.

We are grateful to Mr. A. A. Vahora for carrying out some of the experimental work, and to Mr. R. Branch for the infra-red determinations. The investigations are being continued, and a full account of the above and other related observations will be published elsewhere.

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Bactericidal Action of Oleic Acid against *Mycobacterium avium*

There have been many investigations of the bactericidal action of unsaturated fatty acids against tubercle bacilli[1]; but the mechanism of the effect still remains obscure. I have examined the action of oleic acid on *Mycobacterium avium* (Takeo strain) by Warburg and Thunberg's method, colony count and electron microscope.

The effect of oleate on the colony count was investigated by the ordinary plating method using 'Tween'-agar medium[2], in relation to the concentration and the contact period (Table 1). The cells were killed almost completely after contact with 10^{-3} *M* oleate for 30 min., and with 10^{-4} *M* oleate the viable cells were reduced to 7 per cent. This bactericidal effect was found to depend on the concentration of oleate and the time of contact, and the action was not reversed by washing the treated cells with distilled water.

On the other hand, the oxygen uptake was abnormally enhanced by 10^{-4} *M* oleate, and it was strikingly inhibited below the endogenous uptake by 10^{-3} *M* oleate. With the cell-free crude extract, a different mode of curve was obtained (Fig. 1). The reduction of methylene blue was enhanced by 10^{-5} *M* oleate, and it was inhibited by 10^{-2} *M* oleate. This inhibition was not reversed by washing the treated cells with distilled water; but the cells were able to reduce the dye after grinding them in a ball mill.

From these observations it may be assumed that the bactericidal action of oleate is concerned with the surface structures of the cells. This view was further confirmed by examination in the electron microscope. After treating the cells with 10^{-2} *M* oleate for 60 min., some of their surface structures were disintegrated and their cytoplasmic contents were projected outside the cells. By treating the cells with 10^{-3} *M* oleate, electron-transparent loci were developed, which were located just inside the cell surface; and these seemed to be different from the electron-transparent bodies caused by the intense electron bombardment[3].

Thus I think that oleate may act at some surface loci of the cell structures, so disintegrating them. Then respiration and reduction of methylene blue are inhibited irreversibly, and the cells are killed.

Table 1. Bactericidal Effect of Oleate in Relation to its Concentration and Period of Contact

Conc. of oleate \ Contact period	Percentage survivals		
	30 min.	1 hr.	6 hr.
10^{-2} *M*	0·2	0	0
10^{-3} *M*	7	2·3	0
10^{-4} *M*	99	90	14
None	100	100	96

Each 1 per cent corresponds to 2·1 colonies.

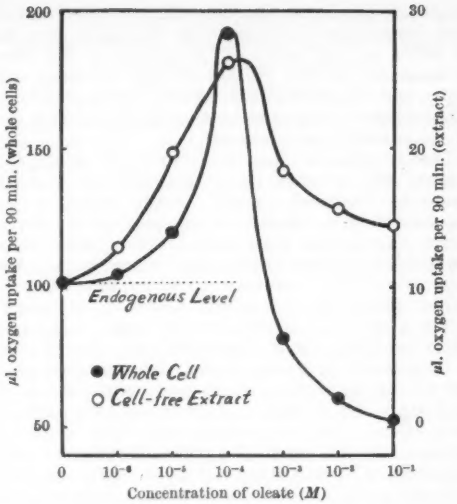

Fig. 1. Effect of concentration of oleate on the oxygen uptake of whole cells and of the cell-free crude water extract

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Progesterone in the Placentæ of Domestic Animals

Progesterone has been isolated from the pre- and post-partum human placenta[1]. It has been assumed, therefore, that it is this placental contribution that enables ovariectomy to be performed during pregnancy without an ensuing abortion. In the mare, cow, ewe and bitch the ovaries may be removed at various stages of pregnancy without inducing an abortion, and thus it has been assumed that the placentæ of these animals also produce progesterone. The evidence in favour of this assumption is based on the finding that when an extract of cow placenta was injected into a rabbit it produced an endometrial response similar to that obtained with

progesterone[2]. It has also been demonstrated recently that ovariectomy performed on pregnant ewes had no effect on the levels of 'progestin' in the blood, as measured by the Hooker–Forbes bio-assay technique, and the levels in fact continued to rise throughout pregnancy in a manner comparable to that seen in sheep with intact ovaries[3].

The purpose of this study was an attempt to confirm the presence of progesterone in placental tissue by chemical means. Fresh placentæ were obtained from a number of sources, and at various stages throughout pregnancy. They were frozen immediately after collection, and stored in polythene bags at −15° C. until they could be assayed.

The extraction procedure consisted of mincing about a kilogram of the frozen tissue, mixing the mince with sand and kieselguhr, and then pressing it in a small hydraulic press. This yielded about 700 ml. of press-juice, which was hydrolysed in the cold with 0·6 *N* sodium hydroxide and extracted with ether. On evaporating the ether extract to dryness, about a gram of a yellow fatty residue was obtained. This was treated with Girard's reagent *T*, and the crude ketonic fraction thus separated was put through a nine-tube counter-current distribution system of methanol and light petroleum, with a partition coefficient of 1 for pure progesterone. The three central tubes of this system should theoretically contain 71 per cent of the progesterone initially present, whereas most of the other ketosteroids remain in the end tubes. The contents of each tube were then taken to dryness, the material dissolved in absolute ethanol, and examined in an ultra-violet spectrophotometer (Unicam). By measuring the optical density of the solution at 240 mμ, it was possible to obtain a rough estimate of the concentration of progesterone. The ethanolic solutions from the central three tubes were then pooled and concentrated to a small volume for chromatographic analysis. This was carried out on paper strips in a methanol/ligroin system at 37° C. for 2 hr.; using this procedure, progesterone had an R_P value of 0·55. The spots were detected by ultra-violet contact photography, and those with the same R_P value as progesterone were eluted from the paper and re-examined in the spectrophotometer.

By this method it has been possible to detect in the placenta of the mare several hundred micrograms per kilogram of press-juice of a substance which appears to be identical with progesterone, in that it has the same partition coefficient, the same R_P value, the same ultra-violet absorption spectrum and the same infra-red spectrum. As a check on the method, one post-partum human placenta was also assayed, and progesterone was detected readily.

On the other hand, using the same procedure, it has not been possible as yet to detect any progesterone in the late-term placentæ of the cow, ewe, sow or bitch. If, in fact, progesterone is not produced by the placenta in these species, it will be interesting to study the mechanism for the maintenance of pregnancy after ovariectomy, and to investigate further the reported biological activity of cow placental extracts and of blood from pregnant ovariectomized ewes.

In contrast to the human placenta, that of the mare is of the non-deciduate, epithelio-chorial type and is assumed to be composed of fœtal tissue only. The demonstration of progesterone in the mare placenta may therefore be taken as an indication that the fœtal tissue itself is responsible for the production of the hormone, or for its selective concentration from the maternal circulation.

I am indebted to Dr. R. K. Callow for carrying out the infra-red analysis, and to Dr. T. Mann and Dr. W. H. Pearlman for helpful advice.

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Site of the Chorioallantoic Inhibitor of Influenza Virus Hæmagglutinin

The chorioallantoic inhibitor of influenza virus hæmagglutinin is destroyed during the multiplication of influenza virus in the allantois[1–3]. It is not, however, destroyed by *V. cholerae* receptor-destroying enzyme inoculated into the allantoic cavity[4], and only partly destroyed when the chorioallantois is exposed to the enzyme *in vitro*[1,4]. Because of this inaccessibility to receptor-destroying enzyme the inhibitor has been taken by most workers to be inside the allantoic cells and therefore potentially an index of the intracellular action of influenza virus enzyme. For example, the finding that massive inocula of virus inactivated by ultra-violet do not destroy the inhibitor has prompted the suggestion[3] that infecting particles lose their enzyme on entering the cell, the only virus enzyme to occur inside cells being that of progeny particles.

Recently, in the course of an investigation of the structure of the allantois, a technique was found for stripping pieces of allantoic endothelium from the chorioallantois. This made it possible to find out if the allantoic cells, even though they constitute less than a tenth of the mass of the chorioallantois, do in fact provide most of the inhibitor. Strips of allantois and the corresponding areas of membrane, free of allantois, were collected from a nine-day embryo. The two tissues were ground, suspended in equal volumes of saline and titrated for inhibitor against heated *LEE* virus[1]. By this test the inhibitor content of the allantois was found to be about one-sixteenth that of the rest of the chorioallantois. A technically easier route to the same result lay in comparing the inhibitor titre of the chorioallantois with that of the allantois covering the yolk sac; large pieces of the latter, containing no major blood vessels, can be stripped off the yolk sac easily and consist of the continuous sheet of allantoic cells backed by only a thin layer of mesoderm. In several such comparisons the chorioallantois was found to contain 10–40 times as much inhibitor, area for area, as the allantois. Further, more than 80 per cent of the inhibitor in the allantois over the yolk sac was shown to be accessible to the action of receptor-destroying enzyme *in vitro*.

Apparently, at least 90 per cent of the chorioallantoic inhibitor lies not in the allantoic endothelium but in the rest of the chorioallantois. The destruction of this inhibitor during virus multiplication implies that the infected allantoic cell liberates virus from its mesodermal surface as well as into

the allantoic cavity. It has yet to be shown: first, that there is any inhibitor inside allantoic cells, and secondly, if there is inhibitor inside the cells, that it is destroyed during virus multiplication.

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Precocious Puberty in Rats with Hypothalamic Lesions

It has recently been found[1] that ferrets, normally anœstrous during winter, become œstrous in January and February within 3–4 weeks after electrolytic lesions have been made in the anterior hypothalamus. The hypothesis was advanced that some hypothalamic mechanism may normally inhibit the pituitary secretion of follicle-stimulating hormone in sexually quiescent individuals, for example, (*a*) during the anœstrum of seasonally breeding animals and (*b*) during infancy. Interference with such a mechanism by destruction of hypothalamic tissue might promote the secretion of follicle-stimulating hormone and so induce sexual activity. The suggestion that inhibition of follicle-stimulating hormone secretion is normally exerted during infancy has now been tested on a series of immature rats.

Seventeen 14- or 15-day old females of an inbred Lister strain were used. Electrolytic lesions intended to be immediately posterior to the optic chiasma were made in nine, and eight were sham-operated. The animals were examined regularly post-operatively and the day of opening of the vaginal orifice (which is an index of the occurrence of puberty) recorded. Two lesioned rats reached puberty at 30 days of age and four at 33 days. The vaginal orifice of one sham-operated animal also opened at 33 days. In a comparable group of twenty-six normal rats only one animal had reached puberty at 33 days while the average age for puberty was 41 days (S.D. $\pm$ 3·7). Examination of the reproductive tract when the rats were killed at 34–35 days of age confirmed that reproductive maturity had been achieved. Ovulation was found to have occurred in the ovaries of five of the six rats in which the onset of puberty was hastened. Histological studies upon the site of the lesion are in progress.

These findings, together with those on the ferrets, seem to support the hypothesis of a mechanism which inhibits follicle-stimulating hormone residing in the anterior hypothalamus. In man, it has been suggested[2] that such a mechanism is located in the posterior hypothalamus.

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Levels of Thyrotrophic and Gonadotrophic Hormones in the Blood of Mature and Immature Female Rabbits

Ten female rabbits were used in this experiment, three immature, three œstrous and four pseudopregnant. The rabbits were rendered pseudopregnant by electrical stimulation of the uterine cervix with a 4·5-V. tetanic current. They were then kept until the eighth day, when the corpus luteum is fully developed[1]. The reproductive state was confirmed by histological examination of the ovaries.

The levels of thyrotrophic and gonadotrophic hormones in the blood of these rabbits were determined by the use of one-day-old chicks[2]. The chicks were injected daily with a subcutaneous injection of 0·50 ml. of plasma for five days. They were then killed by ether 24 hr. after the last injection.

The thyrotrophic hormone level was indicated by its effect on the weight of the thyroid of male chicks, as shown in Table 1. The thyrotrophic hormone in the blood of rabbits is higher during œstrus than during the stages of immaturity or pseudopregnancy. Similar results were obtained in the rat[3].

Table 1. Average Weights of Thyroid and Testes of Chicks injected with Plasma from Immature, Œstrous and Pseudopregnant Rabbits

Treatment	No. of chicks	Average weight of thyroid (mgm./100 gm. body-weight)	Average weight of testis (mgm./100 gm. body-weight)
Control	4	6·11 $\pm$ 0·45*	29·46 $\pm$ 4·62
Immature	6	6·36 $\pm$ 0·47	40·30 $\pm$ 2·37
Œstrous	8	11·64 $\pm$ 0·73	52·54 $\pm$ 4·30
Pseudopregnant	10	9·30 $\pm$ 0·53	53·73 $\pm$ 4·29

* Standard error.

The gonadotrophic hormone level was indicated by its effect on the weight of the testis of chicks. The gonadotrophic hormone in the blood of mature rabbits (œstrous and pseudopregnant) was higher than that in the immature animal. Lauson *et al.*[4] showed that the gonadotrophic hormone content of the rat pituitary drops rapidly at puberty. They suggested at the time that this may be due to an increased outpouring of the hormone into the blood stream. This view is confirmed by the results obtained in the present investigation. The œstrous and pseudopregnant rabbits did not show a significant difference in the levels of gonadotrophic hormone in their blood. The assay method used did not allow a differentiation between the levels of follicle-stimulating hormone and luteinizing hormone factors.

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Mode of Infection of the Nervous System in Poliomyelitis of the Chick Embryo

Inoculation of a chick embryo-adapted *MEF*$_1$ strain of poliomyelitis virus into the yolk sac of chick embryos produces an infection which causes lesions like those observed in primates infected with poliomyelitis[1]. Preliminary studies did not reveal the exact mode of spread of the virus from the yolk sac to the nervous system. The present experiments were designed to elucidate this point by correlating the distribution of histological lesions with the concentration of virus in various tissues during the early stages of infection after introduction of poliomyelitis virus by the yolk sac and by the intravenous routes.

Two groups comprising a hundred seven-day, and ninety-five eight-day old white Leghorn embryos were inoculated by the yolk sac and intravenous routes, respectively, with 200,000 and 16,000 mouse *LD*50 units of virus, derived from the 44th egg passage in the series *R* 382 of the chick embryo-adapted strain of *MEF*$_1$ poliomyelitis virus[2]. Eggs were incubated at 36° C. and live embryos were harvested at frequent intervals for estimation of the virus in the tissues[1], and for histological study. Embryos were fixed in Bouin's solution and serial coronal sections were made of the entire central nervous system, posterior root, sympathetic and cranial nerve ganglia. All pilot slides made at intervals of 9–29 sections were examined; where lesions were found in a nucleus or ganglion without changes in the corresponding ipsilateral or contralateral ganglion or nucleus, every serial section through the apparently unaffected structure was examined.

Specific lesions of the nervous system, similar to those which have been described in poliomyelitis of the chick embryo[1], were first noted 66 hr. after yolk sac, and 48 hr. after intravenous, inoculation of virus (Table 1). The distribution of lesions was independent of the route of inoculation; but the onset and progress of the pathological changes were considerably accelerated when virus was administered by the intravenous route (Table 1). The Gasserian and spinal ganglia and the nuclei of the sixth and seventh cranial nerves were affected early and frequently. Neuronal cytolysis in the trigeminal ganglion preceded detectable changes in the nucleus of the fifth cranial nerve (Nos. 1–4; 2*A* and 3*A*). On several occasions, no lesions could be found in the geniculate ganglion when severe neuronal degeneration was present in the ipsilateral facial nucleus (Nos. 2, 4, 5, 6, 9; 1*A*–3*A*). In three embryos spinal ganglia were affected and the cord was normal (Nos. 1, 2 and 2*A*). Changes in the jugular ganglion preceded those in the vagal nucleus and the ganglion nodosum (Nos. 5, 6; 1*A* and 2*A*). Lesions were observed on the olfactory bulb 92 hr. after yolk sac infection and 48 hr. after intravenous inoculation of virus. The cœliac ganglia were not affected.

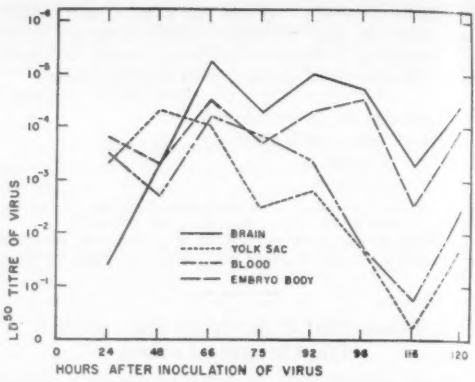

Fig. 1. Distribution of virus in embryos inoculated with 200,000 mouse *LD*50 units of *MEF*$_1$ poliomyelitis virus by the yolk sac route. Note the increase in concentration of virus in the yolk sac and the drop in virus titre of the blood and body fractions between 24 and 48 hr. The titre of the blood rose again when that of the brain reached a peak at 66 hr.

Virus which was introduced into the yolk sac multiplied there and initiated a viræmia (Fig. 1); the virus concentration in the brain rose to a maximum 66 hr. after inoculation (Fig. 1), at which time lesions were first noted in the nervous system. When the virus was inoculated into the blood stream, rapid uptake by the nervous system may be inferred from the high virus titre of the brain and low titre of the blood after 24 hr. (Fig. 2); this was confirmed by the earlier development of lesions in this group (Table 1). The more rapid evolution of the disease which followed intravenous infection, the similarity in the distribution of lesions after introduction of virus by either route and the early involvement of unrelated ganglia and nuclei suggest that virus entered the nervous system at several points directly from the blood stream.

Table 1. Distribution of Specific Lesions of the Nervous System in Chick Embryos infected with *MEF*$_1$ Egg-adapted Poliomyelitis Virus

Route of inoculation	Embryo No.	Hr. after inoculation	Cranial nerve nuclei and ganglia								Spinal cord	Root ganglia	Other lesions (ref. 1)
			V		VI	VII		X					
			Nuclei	Ganglia	Nuclei	Nuclei	Ganglia	Nuclei	Jugular ganglia	Ganglia nodosa			
Yolk sac	1	66	—	*RL*	—	—	—	—	—	—	—	*RL*	—
	2	75	—	*RL*	*L*	*L*	—	—	—	—	—	*RL*	—
	3	75	—	*RL*	—	—	—	—	—	—	*RL*	*RL*	—
	4	92	—	*L*	*R*	*R*	—	—	—	—	*RL*	*RL*	*R*
	5	92	*RL*	*RL*	*RL*	*R*	—	*R*	*RL*	—	*RL*	*RL*	*RL*
	6	96	*RL*	*RL*	*RL*	*RL*	*L*	*RL*	*RL*	—	*RL*	*RL*	*RL*
	7	96	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*R*	*RL*	*RL*	*RL*
	8	116	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*
	9	116	*RL*	*RL*	*RL*	*RL*	*L*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*
	10	120	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*	*RL*
Intravenous	1*A*	48	*RL*	*RL*	*RL*	*RL*	—	*RL*	*RL*	—	*RL*	*RL*	*RL*
	2*A*	75	—	*RL*	*RL*	*L*	—	—	*L*	—	—	*RL*	*RL*
	3*A*	120	—	*RL*	*RL*	*R*	—	—	—	—	*RL*	*RL*	*RL*

R or *L*, lesions present on right or left side; —, lesions absent.

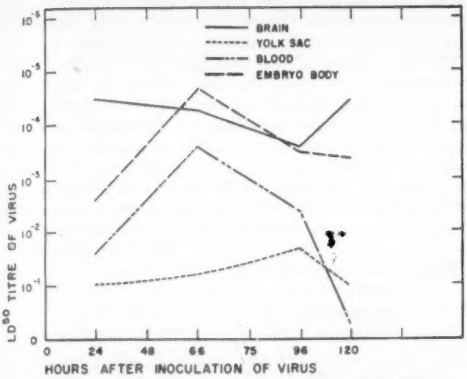

Fig. 2. Distribution of virus in embryos after intravenous inoculation of 16,000 mouse *LD*50 units of *MEF*$_1$ poliomyelitis virus. Note the high virus titre of the brain and low blood titre at the onset. The viral concentration in the body fraction paralleled that of the blood at a slightly higher level. Only small amounts of virus were demonstrable in the yolk sac

The complete results and a more detailed analysis of these experiments will be published in full at a later date.

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Function of the Red Muscle in Fish

DURING investigations of the vitamin contents of different organs from the tunny (*Thunnus thynnus*)[1], samples from the deep-seated red muscle as well as from the neighbouring ordinary muscle were analysed for niacin, riboflavin, pantothenic acid, vitamin B_{12} and thiamine. The results revealed an interesting relative distribution. With the exception of niacin, which showed a slightly higher value for ordinary muscle, the red muscle contained several times more of the other B-vitamins than the ordinary muscle.

These findings were followed up by investigations of other species. Samples were taken from the ordinary white muscle as well as from the lateral muscle (musculus lateralis superficialis) of several teleosts. The elasmobranch porbeagle (*Lamna cornubica*) has also been included in the investigations. This shark has a distinct red muscle section situated in the middle of the white muscle at both sides of the frontal part of the vertebræ. Some representative results are given in Table 1.

The results showed that, apart from niacin, all the other B-vitamins investigated are present in much higher concentrations in the red than in the ordinary muscle, and further that the general distribution in the red muscle is similar to the values found in the liver.

Chemical analysis revealed that in most fishes the red muscle has a much higher fat-content than the neighbouring ordinary muscle; the values of the present samples from mackerel, herring and halibut were about 27–29 per cent. Muscles with such high fat-contents are scarcely suited for strenuous and continued activities. Assuming the red muscle is the less active, it would be expected that under the anaerobic conditions which prevail during the death struggle, the breakdown of glycogen and the formation of lactic acid would be less in the red than in the neighbouring ordinary muscle. Analysis of the red and the neighbouring ordinary muscle in frozen tunny gave the following interesting values: 1 per cent and traces respectively of glycogen, 0·8 per cent and 1·6 per cent respectively of lactic acid.

The red muscle thus contains relatively high concentrations of the B-vitamins, and also myoglobin[2] and cytochrome c [3], which are all part of the enzyme system carrying out oxidative metabolism. It therefore may be concluded that the red muscle is able to carry out similar synthetic processes as those taking place in the liver. If we further consider the relatively frequent high fat-contents in the red muscle, and the fact that the white muscle contains no myoglobin and low contents of the B-vitamins except for niacin, it is likely that the main purpose of the red muscle is not muscular work, but that it functions as an organ.

The exceptional results for niacin, which on an average for the species discussed here was found in equal concentration in both muscles, are in agreement with the special function of this vitamin as part of coenzyme I. This coenzyme plays an important part in carbohydrate metabolism during muscular activity, as well as in several dehydrogenase systems in tissues from different organs. Several enzyme studies are therefore in progress.

Finally, consider the presence of the red muscle in relation to the normal activities of the species. The anatomical situation of the red muscle prevents it taking part in the main muscular work. Further, of the species investigated, the tunny, as a very active and fast-swimming fish, has the highest pro-

Table 1. VITAMIN CONTENTS OF LIVER, RED MUSCLE AND ORDINARY MUSCLE FROM SOME SPECIES OF FISH

Species	Sample of	Niacin (μgm./gm.)	Pantothenic acid (μgm./gm.)	Riboflavin (μgm./gm.)	Vitamin B_{12} (μgm./gm.)	Thiamine (μgm./gm.)
Tunny (*Thunnus thynnus*)	Liver	87	26·0	46·0	3·10	3·7
	Red muscle	100	32·8	7·9	0·38	4·3
	Ordinary muscle	122	5·0	1·5	0·047	2·5
Mackerel (*Scomber scombrus*)	Liver	79	33·3	11·3	0·52	4·0
	Red muscle	97	30·0	13·8	0·11	3·7
	Ordinary muscle	107	3·8	1·6	0·015	0·2
Halibut (*Hippoglossus hippoglossus*)	Liver	30	9·0	7·0	0·89	2·5
	Red muscle	31	5·2	2·5	0·05	0·35
	Ordinary muscle	44	3·6	0·6	0·009	0·40

portion of red muscle. Next come mackerel and herring, which also move rapidly in shoals. On the other hand, halibut, as a flat fish, has less and a paler red muscle. Further considerations along these lines give the same general relation between activity and the extension and pigmentation of the red muscle in different species.

A fuller account of this work will be published later.

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Production of Haploid Plants of Marrow-stem Kale

Haploid maize plants have been obtained in frequencies varying between 0·02 and 0·3 per cent by examining seedlings from plants, homozygous for recessive seedling-colour marker genes, which have been pollinated by plants homozygous for dominant marker genes[1]. In marrow-stem kale (*Brassica oleracea* L. var. *acephala* D.C.), it has been found that non-hairy first leaf is recessive to hairy first leaf. Five plants, homozygous for the recessive gene, non-hairy, and obtained from inbreeding a single selection (plant 220), were pollinated in the bud stage by a single plant (31/11), which was homozygous for the dominant gene for hairy first leaf and which was also a first-generation inbred plant. As is shown in Table 1, a total of 2,674 seedling plants were examined and four non-hairy plants were found.

Table 1

Female parent	Male parent	No. seed sown	No. germ.	Per cent germ.	No. hairy	No. non-hairy	No. haploids
220/2	31/11	285	269	95	269	–	–
220/4	31/11	474	295	62	295	–	–
220/6	31/11	240	238	99	237	1	–
220/9	31/11	952	885	93	884	1	1
220/12	31/11	1,006	987	98	985	2	1
	Total	2,957	2,674		2,670	4	2

When these four non-hairy plants came into flower, three had sterile pollen and two of these had much smaller flowers than normal diploid kale. Measurements of stomata showed that the two with small flowers also had relatively small stomata, 22μ and 23μ long, as compared with 28μ long in normal diploid plants.

Cytological examination of pollen mother cells confirmed that the two plants were haploids with a chromosome number of $2n = 9$. A preliminary examination of fifty-four cells at first metaphase showed thirty-eight cells with no bivalents, twelve with one and four with two. The presence of these bivalents is interesting since it has been suggested from the occurrence of secondary pairing of bivalents that the true basic number in the genus *Brassica* is 6, and that in *B. oleracea* itself "three of the six basic chromosomes are present in duplicate, the other three but once each"[2]. The bivalent frequency would also appear to be higher than that in haploid *Brassica campestris* ($2n = 10$), where only occasional cells with one loosely paired bivalent were seen[2].

The occurrence of the two non-hairy plants, which are not haploids, may be due either to accidental self-pollination, diploid egg cells of the female parent functioning without fertilization, spontaneous doubling of original haploid embryos, or mutations in the pollen of the male parent. It may be possible to show that the last hypothesis is the correct explanation by determination of the self-incompatibility allelomorphs present in the two diploid non-hairy plants.

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Epidiopatra hupferiana Augener from the North-East Pacific

The little-known polychaete genus *Epidiopatra*, belonging to the family Eunicidae, was set up by Augener[1] in 1918 to contain two species, *E. hupferiana* and *E. drewinensis*, both collected off the west coast of Africa. No other species has since been added to the genus. The only subsequent record of either species is that of *E. hupferiana* from South Africa by Monro[2] in 1930. Both Augener's and Monro's specimens were dredged on muddy or sandy bottoms and, in Augener's case, mention is made of their inhabiting tubes.

Capture of a specimen of *E. hupferiana* in a plankton tow, from 100 ft. to surface, in Hecate Strait, British Columbia, seems worthy of record. It was taken by Mr. R. J. LeBrasseur, of this Station, in June 1955. The specimen is small (about 12 mm. long); but the characters are unmistakable. The generic characters are essentially those of the better-known Eunicid genus *Diopatra*, except that tentacular cirri are entirely absent and there is a very limited number of branchiferous segments. In all technical details the specimen agrees completely with Augener's and Monro's descriptions of *E. hupferiana*.

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Two Unifactorial Characters for which Man is Polymorphic

It has been recognized for many years that humans excrete methanethiol (methyl mercaptan) after eating asparagus, and it has been assumed that this character is universal[1,2]. We have found, however, that while some subjects excrete detectable amounts of methanethiol after ingesting only three or four sticks of asparagus, no significant amount of the compound appears in the urine of others after ingestion of as much as a pound of asparagus. Biochemical investigations of this metabolic difference are being made in collaboration with Dr. P. W. Kent. Nencki's[1]

Table 1

Parental phenotypes	Families tested	Children		Total
		Excretors	Non-excretors	
Exc. × exc.	1	1	1	2
Exc. × non-exc.	4	5	7	12
Non-exc. × non-exc.	4	0	11	11

identification of the odorous substance in urine as methanethiol has been confirmed by isolation of the corresponding silver mercaptide.

In a random sample of 115 individuals, forty-six were found to be excretors of methanethiol after eating asparagus and sixty-nine were found to be non-excretors. Limited familial data suggest that the excretor character is controlled by a single, autosomal, dominant gene. The offspring of different mating types are summarized in Table 1.

The second character which we have investigated is the appearance of a distinct red coloration in the urine after eating moderate quantities of beetroot. This has been regarded as a rare anomaly occasionally confused with hæmaturia in medical practice. However, in a random sample of 104 subjects, ten reported that they were distinctly positive for this character; another small survey brought to light four matings in which both partners were positive. The six children of these matings are all positive; this result would occur by chance less than once in a million times, and it therefore suggests strongly that the character is controlled by a single, autosomal, recessive gene. Other family data, which accord with this interpretation, are included in Table 2.

The order of frequency of this character implies that about 43 per cent of the population are heterozygous for the gene; hence the expected proportion of non-excretors to excretors in the progeny of crossmatings is just over 3 : 1. As it happened, in both the families tested the non-excretor parent was known to be heterozygous for the gene and the 1 : 1 ratio expected in such back-crosses was obtained. However, the expression of this character appears to be somewhat variable. Most positive subjects develop a typical red urinary pigmentation whenever they eat beetroot; but in a minority the red pigment appears only intermittently, sometimes being replaced by a dark-brown pigment. The red pigment in urine has the same absorption spectrum as the water-soluble beet pigment, betanin, described by Pucher and colleagues[3], which appears to be a polyhydroxyphenolic glucoside containing two atoms of nitrogen per molecule. The brown pigment sometimes found in urine may represent a decomposition product of this rather unstable compound. Dr. R. B. Fisher kindly allows us to quote his finding that the beet pigment is readily absorbed in isolated rat intestines. If betanin is absorbed in all human subjects, its appearance in the urine of about 10 per cent presumably reflects an inability on their part to metabolize the compound. When tested, two excretors of betanin showed no difference from other subjects in glucose re-absorption in the renal tubules.

Table 2

Parental phenotypes	Families tested	Children		Total
		Excretors	Non-excretors	
Exc. × exc.	3	6	0	6
Exc. × non-exc.	2	2	2	4
Non-exc. × non-exc.	6	2	14	16

It seems that both these characters fall within Ford's definition of polymorphism: "The occurrence together in the same habitat of two or more distinct forms of a species in such proportions that the rarest of them cannot be maintained by recurrent mutation"[4]. If our interpretation of the genetics is correct, in the samples quoted the frequency of the gene controlling methanethiol excretion after eating asparagus, which we propose naming *As*, is 0·23, and the frequency of the gene controlling excretion of beet pigment, for which we propose the symbol *bt*, is 0·31. The fact that these genes and their allelomorphs have remained common in human populations suggests that they are being, or have been, maintained in equilibrium by selective forces which confer an advantage on the heterozygotes. The nature of these forces is at present unknown; but it is possible that, as has already been shown in some blood-groups and hæmoglobin variants[5], the various genotypes differ in respect of susceptibility to disease.

These unifactorial characters identify two additional loci on human chromosomes and should prove of value in tests of genetic linkage.

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Anopheles hyrcanus as a Vector of Filariasis in West Bengal

In a recent epidemiological investigation of the filariasis problem in West Bengal, we have frequently detected the Indian form of the species *A. hyrcanus* var. *nigerrimus* as the vector of filariasis, like its counterpart, *A. hyrcanus* var. *sinensis*, in China and Dutch East Indies[1]. It occurs throughout the entire zone from Narayangarh to Ramnagar, covering the four police areas of Belda, Egra, Contai and Ramnagar in the Midnapore District, excepting, however, a single occasion when bancroftian infection was noted in *Culex fatigans* from the suburbs of Contai. Finger blood of residents in every locality of this zone taken at night during the months February–April 1956 showed a mixed infection of microfilariæ of both *Wuchereria bancrofti* and *Wuchereria malayi*, with the latter predominating.

It is generally known that filariasis in India caused by *W. bancrofti* is transmitted by *Culex fatigans*, whereas that caused by *W. malayi* is carried by *Mansonioides annulifera* and to a lesser degree by *M. uniformis* and a few other allied species[2]. Among the anophelines found casually infected in Nature, mention may be made of *A. philippinensis*[3]; but never before has *A. hyrcanus* been incriminated as a natural carrier in India, although the species along with several other anophelines has long been known as a suitable intermediate host of the parasites under experimental conditions[4].

Investigations are progressing and a report embodying further details will be published elsewhere.

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Marking of Tsetse Flies for their Detection at Night

Most tsetse field-work so far has been based on day-time observations of active flies. If work is to be done on resting flies, it will be advantageous to have an easy method of locating them. It is known[1] that mosquitoes can be dusted with non-toxic materials which fluoresce in ultra-violet light at night, and using this method, mosquitoes can be watched at a distance of about 10 ft. The insects are not sensitive to ultra-violet radiations.

Much experience has been gained of marking the thorax of tsetse with oil paints in the field[2], and this method of applying the fluorescent paints would have many advantages. Luminous paint of the type that shines without excitation by ultra-violet radiation proved (*a*) poisonous to tsetse and (*b*) to give too feeble a glow to be useful under field-conditions.

B.T.H. 'Dayglo' (silica-based organic dyes in ethyl cellulose) powders mixed with a binder and solvent produced a satisfactory paint and were used in a series of tests on house and tsetse flies. The ultra-violet lamp used was worked off 230 volts a.c. It is of interest to note here that a source of ultra-violet radiation has been developed which can be worked off a 6-volt battery. Paint was applied with a sharpened match-stick on the centre of the thorax, covering it without fouling head or wings.

At 15 ft., treated flies shone brilliantly in the ultra-violet beam and the maximum range was 20 ft. The lamp produced much visible light, and the maximum range might well be increased by filtering out the glare. 'Dayglo' paints, when excited by ultra-violet radiation, have a visible glow from 8 ft. in daylight. The ultra-violet light does not appear unduly to disturb *Glossina morsitans*.

Thus there appears to be a promise of success for locating tsetse flies at night by painting the thorax with non-toxic materials which fluoresce under ultra-violet light.

These experiments were carried out in the Department of Entomology at the London School of Hygiene and Tropical Medicine, and I should like to thank Dr. Bertram for allowing the use of the facilities of his Department, Messrs. W. H. Potts and E. F. Whiteside for help and the British Thomson-Houston Co., Ltd., for the supply of materials and demonstration of ultra-violet sources.

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Mortality in the Sheep Ked, *Melophagus ovinus* (L.), caused by *Trypanosoma melophagium* Flu.

The sheep ked is an obligate blood-sucking ectoparasite of sheep; its life-history is well known and has been described by various authors, notably Evans[1]. Hoare[2] has described the life-history of *Trypanosoma melophagium* Flu. and its relation to the ked. The crithidial stage of the flagellate is a normal inhabitant of the midgut of the insect. Crithidia are attached by their flagella to the epithelium of the posterior half of the midgut, and small numbers may be found in the gut lumen. Small masses of the metacyclic, or infective, stage may be seen adhering to the wall of the iliac bulb (rectum) or free in the contents of the bulb.

At the Lethbridge Laboratory, large numbers of keds have often been seen to die on sheep as a result of blockage of the posterior midgut by large masses of crithidia. The gross symptoms of impending death are usually (*a*) swelling of the abdomen, (*b*) development of a reddish-pink colour over the entire insect (indicating escape of sheep's red-blood cells from the gut into the hæmolymph), (*c*) change in colour from brown to white of the iliac bulb, which is distended, violently contracting, and clearly visible through the dorsal integument.

Internally, although the anterior midgut is distended with undigested blood, the posterior midgut is emptied of digestive contents between the pyloric valve and the mycetome. Microscopically, in this region are seen, in addition to crithidia attached to the gut wall, masses of crithidial rosettes that are packed into the lumen. Smears of the iliac bulb contents show large numbers of metacyclic forms mixed with excretory products from the Malpighian tubules. The tubules themselves appear greatly distended; but rarely do they contain any stages of trypanosomes.

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Survival of Normal Rabbits after Appendectomy

The majority of the lymphoid tissue in the alimentary canal of normal rabbits is in the appendix, which in fact contains about a half of the total body complement[1]. It forms an active lymphoepithelial system[2] which interchanges bacterial and tissue cells with the gut lumen.

Different aspects of this process have been shown to have immunological[2] and nutritional significance (ref. 1 and unpublished observations on absorption of radioactive bacteria); but I have not found any publication on the results of curtailing them by

Table 1

No.	Initial weight (gm.)	Date of appendectomy	Date of death	Weight at death (gm.)
32	4.11.52 2,335	10.11.52	23.5.56	2,950
34	4.11.52 2,305	not operated	killed 23.5.56	2,650
36	4.11.52 3,160	13.11.52	26.8.55	3,650
37	13.11.52 3,333	not operated	16.1.53	3,020

appendectomy. I have done this on several dozen rabbits, and they are apparently unaffected by it. Table 1 shows the result of a small controlled survival experiment on stock adult albino rabbits maintained at Guy's Hospital Medical School, which confirms this impression.

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Some Properties of Extracted Protochlorophyll Holochrome

MANY leaf pigments have very different spectral, solubility and physiological properties when in the leaf from those shown when they are extracted and dissolved in organic solvents. Because of this, the pigments in the leaf are assumed to be bound to other substances, probably proteins. This combination has been termed holochrome[1]. As the derivation indicates, the word means complete pigment and designates the pigment as it is combined in the leaf.

In etiolated leaves, protochlorophyll holochrome is transformed by light to chlorophyll-*a* holochrome, whereas isolated protochlorophyll itself is not so transformed (cf. ref. 1). Recently, protochlorophyll has been extracted from dark-grown leaves with glycerine[2] and with buffer solutions[3] in a form that is transformed to chlorophyll *a* by light. This result indicates that protochlorophyll can be separated from the leaf in its holochromatic form. We have endeavoured, therefore, to isolate and characterize the minimum unit of the protochlorophyll complex which can carry on this photochemical transformation.

A partial isolation of an active protochlorophyll complex has been accomplished as follows: bean seedlings (*Phaseolus vulgaris*, var. Blue Lake, Ferry-Morse Seed Co.) were grown in a dark room at about 20–22° C. The etiolated leaves (10 gm.) 10–12 days old were ground in a mortar for 10 min. with 30 ml. of a solution of glycine (0·1 *M*) and potassium hydroxide (0·05 *N*) at *p*H about 9·6. The grinding was done in a dark cold room at about 6° C. The liquid was squeezed through a fine-woven cloth and centrifuged at 10,000 *g* for 15 min. The supernatant was pressed through a French–Milner homogenizer[4] with a pressure of 20,000 lb./sq. in. The homogenate was centrifuged for 1 hr. at 10,000 *g* and the supernatant dialysed in Visking tubing overnight against glycine buffer. The dialysed extract was centrifuged in a Spinco Model *L* centrifuge at 40,000 r.p.m. (approximately 93,000 *g*) for 3 hr.

The pellet contained a much greater proportion of the active protochlorophyll than did the supernatant. The pellet was dissolved in a portion of the glycine buffer solution. This required thorough stirring and standing for several hours. Illumination of the dissolved pellet produced chlorophyll *a* (cf. Fig. 1). Sedimentation analysis of this solution by means of a Spinco Model *E* ultracentrifuge showed the presence of two well-separated boundaries (cf. Fig. 1, inset) with sedimentation coefficients of about 4 and 16 Svedberg units respectively. The faster-moving of these boundaries was correlated with the active protochlorophyll complex. Sedimentation diagrams of the extract made before obtaining the pellet showed a much greater proportion of the slower-moving boundary than did those of the resuspended pellet (cf. Fig. 1, inset).

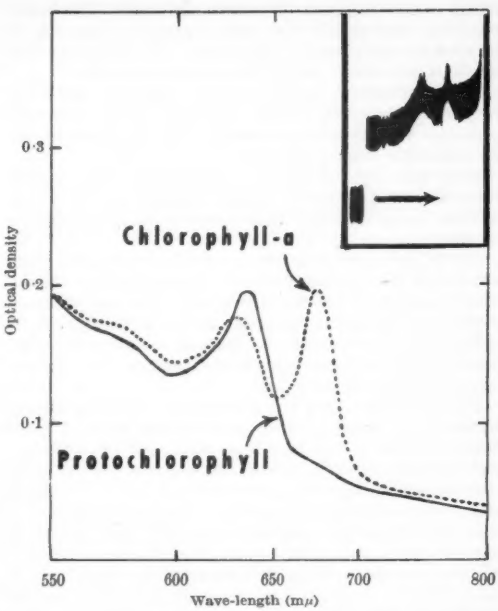

Fig. 1. Absorption spectra of the dissolved pellet, obtained by centrifuging at 40,000 r.p.m. a dialysed extract of etiolated bean leaves before (solid line) and after (broken line) being illuminated. Inset: Sedimentation pattern at 50,740 r.p.m. in synthetic boundary cell. Leading boundary is associated with the photo-transformed material; the trailing peak is near the initial synthetic boundary

In the analytical ultracentrifuge, the solutions were of necessity illuminated. The following observations, therefore, relate to the derived chlorophyll-*a* complex.

No obvious heterogeneity in particle size was indicated, since the spreading of the leading boundary during sedimentation was not extensive and appeared to be symmetrical. The sedimentation coefficients (s_{20}) obtained for several preparations, and measured at different stages of preparation, ranged from 15·3 to 16·2 Svedberg units. The boundary showed no artificial sharpening, nor did its rate of movement depend significantly on the concentration of the solution. Comparison of the s_{20} values with those published for various globular proteins suggests that the molecular weight of this protochlorophyll complex is about 400,000.

In other experiments, subsequent to dialysis against glycine buffer, the extract was further dialysed rapidly against several changes of distilled water and then lyophilized. The solid obtained was slightly yellow and was readily dissolved in aqueous solutions above *p*H 6. Such solutions exhibited the characteristic absorption spectrum in the red of protochlorophyll holochrome and, after being illuminated, that of chlorophyll-*a* holochrome. In the blue region of the spectrum the characteristic absorption of these pigments was not distinguishable

owing to the presence of yellow pigments. The solid material was stable for months when kept in a darkened cold-room. Obviously, no diffusible co-factor is necessary for this photo-conversion.

The lyophilized solid material did not give up its protochlorophyll when extracted with absolute acetone. When aqueous acetone was used, however, the pigment was extracted.

Although the particles containing the active protochlorophyll have not been isolated in pure form, various tests indicate that they consist largely of protein.

From these experiments it may be concluded that a fraction has been separated from etiolated leaves which contains particles of uniform size that possess properties similar to those of native protochlorophyll holochrome in respect to spectral absorption, pigment solubility, and photo-conversion to chlorophyll-*a* holochrome.

In a recent issue of *Nature*[5], J. W. Lyttleton directed attention to two cytoplasmic protein fractions of leaves which had been obtained by Wildman and his co-workers[6]. These fractions possessed sedimentation coefficients, s_{20}, of 3–4 and 16–17 Svedberg units respectively. Lyttleton's own results suggested that the faster-moving fraction "is found only in photosynthesizing tissue or in tissue which is capable of photosynthesis after it is exposed to light". It is instructive to note that we have obtained two similar fractions from etiolated bean leaves, and that the faster sedimenting of these contains protochlorophyll attached in such a way as to be converted by light to chlorophyll *a*. This observation likewise suggests a role for this fraction in photosynthesis.

We are grateful to the Chemistry Department of Stanford University for making available the Spinco centrifuges for this work. During the first part of this investigation, one of us (D. W. K.) was associated with the Chemistry Department of Stanford University as a Fellow of the U.S. Public Health Service.

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Occurrence of the Methylene-dioxy Bridge in the Phenolic Components of Plants

The methylene-dioxy bridge $\left(\begin{matrix}-O\\-O\end{matrix}\right)CH_2$ is a common feature of the structure of several groups of plant alkaloids and occurs also, though less commonly, among natural phenolic substances. Geissman and Hinreiner[1], in a recent review of natural phenols, list twenty-four different substances containing the methylene-dioxy bridge; fourteen of them are C_6—C_3 type and all are characterized by a generally high degree of methylation of hydroxyl groups in the molecule; indeed, none of them bears a free hydroxyl in the ring that bears the bridge. The alkaloids are similarly characterized by a high degree of methylation of phenolic hydroxyl groups[2]. Botanically, the methylene-dioxy phenolic substances are distributed widely but not haphazardly, for they occur in six families of Polypetalae (Anonaceae, Magnoliaceae, Rutaceae, Leguminosae, Rosaceae and Umbelliferae), three of Apetalae (Myristicaceae, Lauraceae and Piperaceae) and one of the monocotyledons (Orchidaceae). Of these families, Lauraceae and Piperaceae are much the most abundant sources, and it seems from this (as from the occurrences in Magnoliaceae, Rutaceae, Umbelliferae and Myristicaceae) that there may be some relationship between aromatic properties and the occurrence of the bridge. It may be significant, too, that of the eleven families of plants which have yielded methylene-dioxy alkaloids, no fewer than four occur in the above list of phenolic-bearing families (Anonaceae, Rutaceae, Leguminosae and Piperaceae[3]).

In a general survey of phenolic substances in the leaves of plants, Bate-Smith[3,4] recommends the use of a toluene/acetic acid/water solvent for chromatography; this solvent has the useful property of immobilizing the commoner natural phenols except the cinnamic acids (ferulic, sinapic and *p*-coumaric) and the related coumarins (scopoletin and umbelliferone). Of these substances, ferulic acid, R_F 0·25, is the most mobile, so that the lower portion of the chromatogram is commonly empty. Occasionally, however, leaf extracts are encountered which yield blue spots giving violet or green fluorescence under ultra-violet light, that run in advance of ferulic acid. Apart from the uncommon 7-methoxycoumarin, herniarin, which, we are informed (personal communication from Dr. E. C. Bate-Smith), has R_F 0·9 approximately in the toluene/acetic acid/water solvent and has a deep-violet fluorescence under ultra-violet light, it is very difficult to make any plausible guesses as to their identities.

It now seems that the occurrence of methylene-dioxy bridges may furnish at least a partial explanation of these fast-moving spots. In support of this statement are the following experimental results. 3 : 4-Methylene-dioxy cinnamic acid was prepared from piperonal by a Dobner condensation (Johnson[3]; melting point 234°–36° (uncorr.); Johnson gives melting point as 233° (corr.)). It gave the following R_F values (corrected by R_M values to known standards run on the same paper[3]): in the Forestal solvent (hydrochloric acid, 10/acetic acid, 100/water, 30), 0·93; in toluene/acetic acid/water (40 : 10 : 50), 0·86; in butanol/acetic acid/water (40 : 10 : 50), 0·89. Under ultra-violet light, it fluoresced dull violet; it was light blue in acid vapour and faded until almost invisible in ammonia. It did not react with diazotized *p*-nitroaniline, whereas herniarin gives a yellow colour with this reagent[4]. A substance which agreed precisely in its R_F in all three solvents and in its ultra-violet fluorescence colours was found in the leaves of *Piper tuberculatum*. If these results be accepted as provisional proof of identity, then this is at once the first record of natural occurrence of the substance and a demonstration of the nature of one of the uncommon fast-moving phenolics in plant extracts. It is surely significant that it occurred in the Piperaceae—the plant, indeed, was chosen for investigation on the basis of the introductory remarks made above. A limited survey of the leaves of plants

representing families in which methylene-dioxy bridges are known to occur yielded the following results (numbers of 'fast phenolic' spots in the toluene/acetic solvent are given in brackets):

Family	Results
Magnoliaceae:	*Magnolia grandiflora* (0)
Anonaceae:	*Canangium odoratum* (0); *Monodora grandiflora* (0)
Rutaceae:	*Murraya exotica* (4); *Citrus aurantifolia* (1); *Citrus paradisi* (1)
Umbelliferae:	*Eryngium foetidum* (0)
Lauraceae:	*Persea gratissima* (0); *Cinnamomum camphora* (0)
Piperaceae:	*Piper tuberculatum* (2); *Piper marginatum* (3); *Piper nigrum* (0); *Pothomorphe peltata* (0); *Peperomia pellucida* (0)

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The Practical Synthesis of l-Phenazinol

Considerable interest has been aroused in 1-phenazinol because of its relatively high antibiotic activity, as brought out in numerous reports, such as in that by Zweig[1]. The methods generally advocated for its preparation, however, are not very satisfactory. Thus the procedures of Surrey[2], and of Hegedüs[3], are time-consuming, while the preparation through pyocyanine obtained from *Pseudomonas pyocyanea* cultures suffers from low yield of the pyocyanine[1]. Poor yield, in this instance of the intermediate 1-methoxyphenazine, also hampers the preparation of 1-phenazinol given by Yoshioka[4].

It has been found that two procedures, already well known in the literature, can be conveniently combined to give a practical means of preparing 1-phenazinol. Phenazine, now readily available by purchase or by synthesis[5], is combined with dimethyl sulphate to produce the quaternary salt, and from this pyocyanine is formed by McIlwain's photochemical synthesis[6]. The pyocyanine, without being isolated, is then converted to 1-phenazinol by the method of Wrede and Strack[7].

The details of the procedure are as follows.

Preparation of 5-methylphenazinium methyl sulphate (phenazine methosulphate). For the sake of completeness, what is essentially the method of Kehrmann and Havas[8] is detailed here. A solution of 25 gm. of phenazine in 125 c.c. of nitrobenzene was heated to about 130° and when it had cooled to 120° it was immersed in an oil-bath heated to 115°. Then, all at one time, 35 c.c. of freshly distilled dimethyl sulphate was added, with stirring. The stirred mixture was kept at 105–10° for five minutes, then removed from the bath. Spontaneous precipitation on cooling gave 35 gm. of bright orange crystals, after removal of adherent nitrobenzene by anhydrous ether.

Conversion to 1-phenazinol. A solution of 4·3 gm. of the unrecrystallized methosulphate in 3·5 litres of distilled water[6] was exposed in an open flask to sunlight through a window for three days, during which the Sun was unclouded for about two-thirds of the time. Then a solution of 80 gm. of sodium hydroxide in about 250 c.c. of water was stirred in, and the reaction mixture allowed to stand for 16 hr. Filtration through fine porosity paper and one extraction with ether were then employed to remove the phenazine and other by-products of the reaction.

The aqueous solution was next made faintly acid with glacial acetic acid, and extracted twice with ether. Evaporation of the ether left 1·5 gm. of crude 1-phenazinol. This was purified by slow vacuum sublimation at about 0·1 mm. from an oil-bath at 115°, giving 1·1 gm. of 1-phenazinol, shrinking at 158·6°, and melting at 159–160° (corr.). The yield of the pure product is 33 per cent, based on the phenazine, and 40 per cent, based on the methosulphate.

(To determine the effect of lessening the large volume, 4·3 gm. of phenazine methosulphate was dissolved in 1 litre of water, and subjected to the same treatment as was given to the more dilute solution. In this instance only 0·94 gm. of crude 1-phenazinol was obtained. It was not determined whether longer exposure to sunlight would increase the yield from this more concentrated solution.)

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Observation of Atmospheric Sodium in Absorption

Nearly twenty years ago, the presence of sodium in the upper atmosphere was found by the observation of the *D* lines in twilight[1]. Attempts to deduce the amount of sodium in the layer suffer from an unknown correction for self-absorption[2]. It is therefore of interest to try to observe the sodium by its absorption; but this is difficult with sunlight because of the strong Fraunhöfer lines originating in the Sun itself. An attempt was made by Sanford[3] using the star α Virginis as a source; here the stellar and interstellar *D* lines are shifted by the Doppler effect so that they do not interfere. He found a faint line which may have been telluric *D*1, and deduced a corresponding upper limit of $1 \cdot 0 \times 10^{10}$ atoms/cm.^{2} for the 'thickness' of the layer, as we may call it.

To observe the telluric absorption in sunlight an instrument is needed giving high resolution and little stray light. We have achieved these by making use of resonance scattering by sodium vapour at a temperature of about 150° C.; the scattered light is recorded by a photoelectric spectrometer[4] which separates the two *D* lines. The system is calibrated by means of light from a tungsten lamp, which, of course, has no absorption lines. The result is a value of the intensity at the bottom of each *D* line as a fraction of the nearby continuum. Between noon and sunset the path-length through the sodium layer varies by a factor of 2–3, depending on the season. A slight decrease in the residual intensities

was in fact observed. Two tests showed that the effect was due to sodium rather than water vapour, which has many lines in the yellow. The variation in $D1$ was less than that in $D2$ by a factor averaging 0·59, which compares well with the expected 0·50. A large drop in the absorption was found in April compared with January and February; this agrees with the behaviour of sodium observed in twilight[2] but disagrees strongly with the behaviour of water vapour.

The thickness of the sodium layer was found from the slope of a plot of logarithm of intensity against relative path-length. Eleven of these from the months December, January and February gave thicknesses between $2{\cdot}5$ and $8{\cdot}3 \times 10^9$ atoms/cm.^{2}; twilight observations give about 3×10^9. Two in April gave $1{\cdot}06$ and $0{\cdot}88 \times 10^9$ atoms/cm.^{2}, in good agreement with twilight observations. It may be concluded that twilight intensities are lowered appreciably by self-absorption in winter but by no more than a factor of about 2.

The plots may be extrapolated to zero path-length to give the residual intensity of the solar D line, averaged over the whole of the Sun's disk. Our results are $(5{\cdot}9 \pm 0{\cdot}46)$ per cent for $D1$ and $(5{\cdot}06 \pm 0{\cdot}24)$ per cent for $D2$, in fair agreement with previous work[5].

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Hydrogen Isotope Exchange

There appears to be some confusion[1–3] in the derivation and application of certain relationships featuring the separation factor for hydrogen (H) and deuterium (D) chemical-exchange processes.

(1) *Derivation of equations.* Consider the following general reaction involving chemical exchange between isotopes I and I'. Let only n_2 of the total n_1 atoms of I and I' in the compound with A be exchangeable, that is, n_4 atoms of I are fixed, and assume that the concentration of I' is very small:

$$\underset{(a)}{AI_{n_4}I_{n_2}} + \underset{(b)}{BI_{n_2-1}I'} \rightleftharpoons \underset{(c)}{AI_{n_4}I'_{n_2-1}} + \underset{(d)}{BI_{n_2}} \qquad (1)$$

where $(n_4 + n_2) = n_1$.

If a, b, c and d ($d \gg b$ and $a \gg c$) denote the concentrations of the respective molecular species in the reaction, the equilibrium constant K_s is given by:

$$K_s = \frac{c.d}{a.b} \qquad (2)$$

The separation factor α may be defined by the ratio,

$$\alpha = (I'/I)_A/(I'/I)_B \qquad (3)$$

but this requires amplification. Thus, the value α_1 based on the total number of I, I' atoms present in compound A is different from the value α_2 based on only the exchangeable atoms. For the former case (which is the more useful since experimental analysis usually includes all atoms I and I') it is seen from equation (1) that,

$$(I'/I)_A = \frac{c}{a(n_4+n_2)+c(n_4+n_2-1)} \rightarrow \frac{c}{a(n_4+n_2)}$$

$$(I'/I)_B = \frac{b}{dn_2+b(n_2-1)} \rightarrow \frac{b}{dn_2}$$

which in combination with equations (2) and (3) give

$$\alpha_1 = \frac{c.d.n_2}{a.b.(n_4+n_2)} = \frac{n_2}{n_1} \cdot K_s \qquad (4)$$

Similarly, α_2 may be obtained as:

$$\alpha_2 = \frac{n_2}{n_2} \cdot K_s \qquad (5)$$

Clearly, if all sites in compound A are exchangeable, that is, if $n_4 = 0$, then α_2 will be identical with α_1; and if the distribution of I and I' be uniform, then α_2 (by definition) will be close to unity.

The equilibrium constant in the above equations may be replaced by the quantum statistical relationship:

$$K_s = \left(\frac{\text{Reactants}}{\pi\sigma} \Big/ \frac{\text{Products}}{\pi\sigma}\right) \cdot f(\nu) \qquad (6)$$

where π is the multiplication operator, σ is the symmetry number (which for any one of the molecules taking part is the number of equivalent orientations in space that that molecule can assume as the results of simple rotation) and $f(\nu)$, which generally tends to the value unity when heavy molecules and moderate temperatures are considered, is a function of the vibrational frequencies.

(2) *Equivalence of position.* It has been assumed that all sites in compound A which partake in exchange are identical. If these positions are not equivalent, for example, if different types of bond or force constant are involved (as in equation 6), then the equations are not strictly applicable.

(3) *Molecular symmetry.* Molecular symmetry is of no importance in deriving equations (3) and (5), and only the numbers of similar sites available for, or excluded from, exchange are concerned[4]. Thus, the equation presented by Gold and Satchell[1], namely:

$$\alpha_2 = \left(\frac{\text{Products}}{\pi\sigma} \Big/ \frac{\text{Reactants}}{\pi\sigma}\right) \cdot K_s \qquad (7)$$

does not represent the general case. Only if both the n_2 exchange sites in the molecule and the molecule $AI_{n_4}.I'_{n_2}$ itself are symmetrical (for example, the three H atoms in ammonia or the two H atoms in aniline) is equation (7) identical with equation (5). In many instances, this condition is not satisfied. For example, by use of a suitable substituent, a nuclear mono-substituted aniline may be obtained which although asymmetrical still possesses two identical amino-group hydrogen atoms capable of exchange. It can be seen that, in this case, equations (5) and (7) differ by a factor of two.

(4) *Application: simple cases.* Consider reactions of the type,

$$AH_{n_4}H_{n_2} + HDO \rightleftharpoons AH_{n_4}H_{n_2-1}D + H_2O \qquad (8)$$

Under mild conditions at 25° C., it has been found[3] for amyl alcohol ($AH_{n_4}H_{n_2} = C_5H_{11}.OH$) that

$\alpha_1 = 0{\cdot}0912$, and for phenol[3] ($C_6H_5.OH$) that $\alpha_1 = 0{\cdot}1824$. On applying equation (4), both these results give $K_s = 0{\cdot}55$ (expected from equation (6) for asymmetric molecules), and from equation (5), assuming only the hydroxyl-H atom exchangeable, the corresponding value of α_2 is $\alpha_2 = 1{\cdot}10$ (see section (1) above). It is seen that for mono-functional cases[1] $\alpha_2 = 2K_s \simeq 1{\cdot}0$.

For benzene[3], where six identical H atoms are capable of exchange, equations (4) and (5) give $\alpha_1 = \alpha_2 = K_s/3 = 1{\cdot}0$.

Values of α_1 are of significance in preparing labelled compounds or in separating hydrogen from deuterium. For example, in the above cases, a D/H ratio equal to that of the water can be obtained in the benzene, whereas only a tenth of this ratio can be secured in the amyl alcohol.

(5) *Application : nuclear aromatic exchange.* Under certain conditions, a substituted benzene compound, for example, phenol, may exhibit slow nuclear deuteration in addition to rapid exchange of the functional hydrogen atom (in this case, the hydroxyl-hydrogen atom) and it is required to know what positions are being affected.

In sections (1) and (4) above, it was shown that $\alpha_2 = f(\nu) \simeq 1{\cdot}0$ for H/D exchange at certain O—H and C—H positions (compare S—H bonds[1]). If it is assumed that substitution of benzene has little effect upon the vibrational frequencies (see sections (1) and (2) above), then α_2 will remain equal to unity for the H/D distribution in the nucleus of the deuterated phenol. Thus, after methylation to yield the nuclear-deuterated anisole ($AH_{8-n_2}.D_{n_2}$), that is, elimination of the deuterated hydroxyl group, a value of α_1 of $0{\cdot}342$ is obtained[3]. From this figure, K_s is $1{\cdot}37$ (compare ref. 1) and, assuming $\alpha_2 = 1{\cdot}0$, the corresponding value of n_2 is $2{\cdot}74$; hence, three nuclear positions (presumably the *ortho-* and *para-* sites) are capable of exchange.

It should be noted[3] that, in these operations, it is α_2, and not α_1 or K_s, which is placed equal to unity.

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Deformations of Metal Surfaces under Normal and Inclined Loads

The purpose of this communication is to offer an explanation of why oxide and other protective films, as measurements of electrical resistance[1] and transfer[2] have shown, are less disrupted when two metal surfaces are loaded together normally than when the loading has a tangential component and the surfaces slip. The suggested explanation is that under normal loading, even though the surfaces be permanently dented, there is a surface layer of material which is not plastically deformed, whereas if the loading be sufficiently inclined the plastic deformation extends to the surface.

It is a result of the theory of the contact of elastic bodies in circumstances of normal loading[3] that the stress responsible for plastic yielding, which will here be taken as the maximum shear stress, has a value proportional to the mean pressure over the area of contact and occurs at a depth proportional to a dimension of that area. The variation of the shear stress with depth is illustrated in Fig. 1. The full line indicates the shear stress at the limiting normal load for elastic conditions, P_C. Plastic deformation is imminent at a point d_C beneath the surface where the maximum shear stress has reached half the yield stress (Y) of the material. Let it be assumed that when the load exceeds P_C the nature of the stress field remains the same, in particular that the maximum stress still occurs at a depth proportional to the pertinent dimension of the contact area, and that because of the flow, the maximum of the shear stress is limited to $0{\cdot}5\,Y$. The variation of shear stress with depth which then exists is illustrated by the dotted line in the figure. Clearly, as the load, area of contact and therefore the depth of the point of maximum stress increase, the stresses in the region from the surface to the depth d_C decrease. Consequently, this region is always protected from plastic yielding and there is a surface layer which is not plastically deformed.

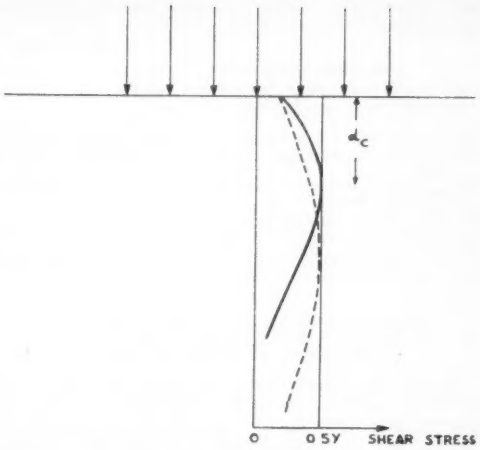

Fig. 1. The variation of the shear stress with depth when the loading is normal

Poritsky[4] has calculated the stresses which exist in cylinders making line contact when the loading is inclined. Under purely normal loading the shear stress perpendicular to the line of contact is zero at the surface while with a sufficient tangential component this stress is very close to the maximum shear stress. In the latter circumstance an undeformed surface layer is not to be expected.

It follows from the above argument that the protective surface films are less disrupted when the loading is normal; indeed, they may not be broken at all. In addition to providing an explanation of the resistance and transfer experiments already referred to, this also affords an explanation of the lack of adhesion between normally loaded metal bodies when their surfaces are contaminated[5] and provides a reason why a tangential force is needed to induce the formation of welds[6].

Direct metallographic evidence of the undeformed layer has been obtained from mild steel disks run together at a load in excess of that which they could

carry elastically. This evidence will be published elsewhere[7].

A. W. Crook

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston, Berkshire. June 27.

[1] Cocks, M., *Nature*, **170**, 203 (1952); *Proc. Phys. Soc.*, **67**, 238 (1954).
[2] Kerridge, M., "Radioisotope Techniques", 2, 26 (H.M.S.O., London, 1951).
[3] Timoshenko, S., "Theory of Elasticity", 337 *et seq.* (McGraw-Hill, New York, 1934).
[4] Poritsky, H., *J. App. Mech.*, 17, 191 (1950).
[5] McFarlane, J. S., and Tabor, D., *Proc. Roy. Soc.*, A, 202, 224 (1950).
[6] Hirst, W., and Lancaster, J. K., *Proc. Roy. Soc.*, A, 223, 324 (1954).
[7] *Proc. Inst. Mech. Eng.* (in the press).

Angular Distribution of Submarine Daylight in Deep Water

In an important paper of 1945, H. H. Poole[1] considers the assumption, suggested in fact by experiments, that at a certain depth in the sea an equilibrium is reached below which the angular distribution of the luminance is constant and independent of the surface-lighting, and the decrease of luminance is an exponential function of the depth characterized by a coefficient of extinction less than (or equal to) the coefficient of total absorption in sea water for a parallel beam. I have recently studied again the problem of the penetration of light in the sea[2], starting from the 'equation of transfer' of the radiation in a scattering medium, and I have found by this theoretical method the existence of an equilibrium condition; the results obtained by an approximate solution of the equation of transfer, in the deep layers, are in good agreement with those given by the direct method of Poole at equilibrium.

Poole's computations used the assumption of isotropic scattering for sea water; this assumption leads to results of simple mathematical form, but unfortunately it is disproved by the reality, as is seen both from the conclusion of Poole and the direct measurements[3]. I have compared these values with those obtained by my method, starting from the assumption of a scattering function with a forward maximum, which corresponds approximately to the actual scattering due to large transparent particles. Adopting the notation of Poole, c is the coefficient of total absorption (true absorption and scattering)

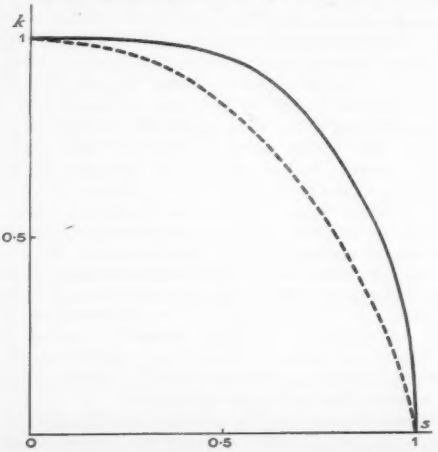

Fig. 1

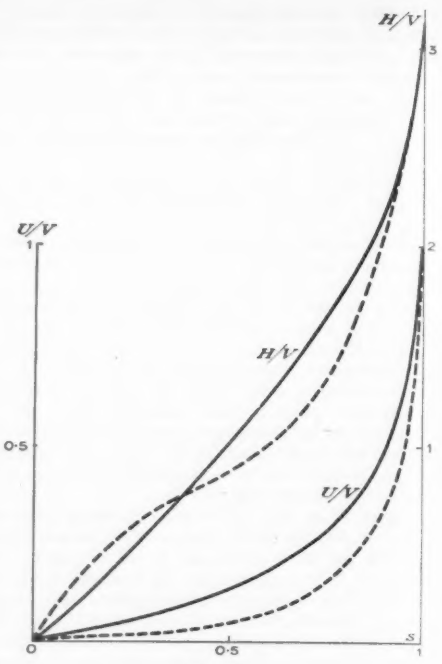

Fig. 2

for water, sc the coefficient of absorption due to scattering (both for a parallel beam), and kc the coefficient of vertical extinction for radiation at equilibrium in the sea; for the chosen scattering function, the coefficient of scattering in a direction at an angle θ with the direction of incidence is $\frac{sc}{4\pi}[1 + 1{\cdot}73\ P_1(\cos\theta) + P_2(\cos\theta)]$, where P_n is the Legendre polynomial of order n. If U is the illumination measured by a plane photometer facing downwards, V the illumination measured by a plane photometer facing upwards, and H the illumination measured by a cylindrical photometer with its axis vertical, Figs. 1 and 2 show the variation of k and of the ratios U/V and H/V with s. The curves in full lines are reprinted from Poole's paper and correspond to the isotropic scattering; the dotted curves are deduced from my computations for the scattering function given above.

In his paper, Poole gives some experimental measurements[4] of U/V and H/V, from which he deduces, by means of curves, two values of s, respectively called s and s'. These results are given in Table 1, together with values of s and s' deduced from my curves; the latter figures are in much better agreement among themselves. So it seems, as was foreseen by Poole, that a scattering function

Table 1

Measurements	Isotropic scattering s	Isotropic scattering s'	Scattering with forward maximum s	Scattering with forward maximum s'
C_1	0·275		0·53	
C_5	0·189	0·42	0·44	0·47
C_4	0·176	0·40	0·42	0·43
C_3	0·169	0·37	0·40	0·37
C_6	0·167	0·40	0·40	0·44
C_7	0·123	0·40	0·35	0·43

with a large forward maximum corresponds much better to reality than an isotropic scattering.

J. LENOBLE

Laboratoire de Physique Appliquée
du Muséum National d'Histoire Naturelle,
Paris. May 17.

[1] Poole, H. H., *Sci. Proc. Roy. Dublin Soc.*, **24**, 29 (1945).
[2] Lenoble, J., *C.R. Acad. Sci., Paris*, **241**, 567 and 1407 (1955); *Rev. d'Opt.*, **35**, 1 (1956).
[3] Atkins, W. R. G., and Poole, H. H., *Sci., Proc. Roy. Dublin Soc.*, **26**, 313 (1954).
[4] Atkins, W. R. G., and Poole, H. H., *J. Mar. Biol. Assoc.*, **24**, 271 (1940).

New Zealand Coals

IN the past twenty years many hundreds of ultimate analyses and many thousands of proximate analyses of New Zealand coals have been made in accordance with British Standard Specifications at the Coal Section of the New Zealand Dominion Laboratory. A preliminary study of these analyses shows that New Zealand coals, varying in rank from peat to semi-anthracite (the anthracites are contact-metamorphosed lignites), almost all belong to a restricted range of coal type different from that of British and North American coals of Carboniferous age.

New Zealand's principal coal seams are of early Senonian to early Oligocene age, but a few Miocene coals are also worked and thin seams occur in younger beds, even as young as early Pleistocene. The rank of the coals, however, appears to be a function neither of age nor of intensity of deformation, but rather of depth of burial.

The seams are usually particularly low in ash, frequently with less than 2 per cent. Coals with high or moderate sulphur contents are widely distributed, the sulphur content bearing a close relation to the stratigraphic distance from marine beds (cf. Wellman[1]). Fig. 1 is a graph, in which the percentage of carbon is plotted against the percentage of hydrogen, for coals with not more than 0·6 per cent sulphur and 7·0 per cent ash, and shows also the 'coal band' for New Zealand coals, extended tentatively to peats. Some of the low-rank coals (in particular some of those with 65–70 per cent carbon) contain abundant resin, with consequent high hydrogen contents, so that some analyses fall above the band. Adjustment of analyses of high- and medium-sulphur coal to a sulphur-free basis cannot be made by the commonly used Parr formula, as the sulphur is almost exclusively organic. Accordingly, these coals are not shown on Fig. 1; but preliminary examination of the analyses shows that most fall within the coal band based on low-sulphur coals.

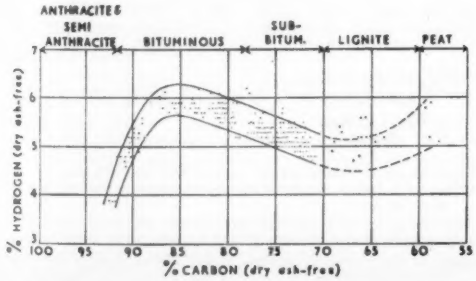

Fig. 1. The New Zealand coal band; coals with not more than 0·6 per cent sulphur and 7 per cent ash

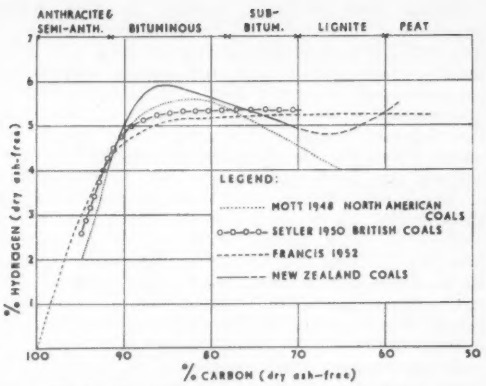

Fig. 2. Mean lines for coal bands of various authors

In Fig. 2 the mean line for the New Zealand coal band is compared with the mean lines adopted by Mott[2] for North American coals, Seyler[3] for British 'bright' coals, and Francis[4] for 'mean ulmins'. These lines trace the metamorphic development of coals of particular types from peat to anthracite. Mott found that those British coals with high durain contents require a subsidiary band of slightly lower hydrogen content than his band for North American coals, but that the difference diminishes with increasing rank; he thus acknowledged that coals of different types would fall in different bands. Likewise, Francis showed different theoretical development curves for perhydrous ulmins and sub-hydrous ulmins.

The scarcity or lack of Carboniferous coals of subbituminous, lignite and peat ranks made it necessary for Seyler to extend his coal band from bituminous to lower ranks on the assumption that the mean hydrogen percentage is nearly constant. Francis' theoretical development curve produces a similar result. Mott's coal band, deduced from Carboniferous, Cretaceous and Tertiary coals, shows an increasing hydrogen content from low-rank lignite to bituminous coal; and the New Zealand coal band, based on coals averaging higher hydrogen contents, shows a comparable, though smaller, increase. Thus Seyler's and Francis' theoretical paths of development for coals of low rank do not appear to be borne out in practice.

R. P. SUGGATE

Geological Survey,
P.O. Box 2110,
Christchurch,
New Zealand.
April 17.

[1] Wellman, H. W., *N.Z. Geol. Surv. Bull.*, 45, 100 (1952).
[2] Mott, R. A., *J. Inst. Fuel.*, 22, 2 (1948).
[3] Seyler, C. A., Coal Petrology in "Progress in Coal Science" (Butterworths, London, 1950).
[4] Francis, W., *J. Inst. Fuel*, **24**, 15 (1952).

African Pleistocene Pluvials and European Glaciations

THE most recent book on African prehistory by Mlle. H. Alimen[1] continues to adopt the theory of three pleistocene pluvials and two interpluvials. Her field-work having been mainly in the Sahara, this must be taken as her considered interpretation of phenomena in this part of Africa.

About 1950, however, Leakey in East Africa proposed to divide the Second or Kamasian Pluvial into two[3], thus postulating four pluvials and three interpluvials. This had the advantage of appearing to correspond with the four glaciations and three interglacials of the northern hemisphere. But while the Second Northern Interglacial was longer and warmer than the other two, Mortelmans in the Congo[3] and van Riet Lowe and other workers in South Africa could not find evidence that Leakey's Second African Interpluvial was as severe as the Third, and it still seemed to be a minor oscillation which scarcely justified dividing the Second or Kamasian Pluvial. In 1952 Leakey[4] stressed the faunal break in East Africa during the Second Pluvial, in order not only to justify but also to emphasize the severity of the interpluvial which he had postulated.

Whatever may have happened in the southern hemisphere, it would indeed be surprising if the great ice-sheets in the northern hemisphere did not have a marked effect on climate in low latitudes, at least as far as the equator. To-day, explanations of the pleistocene ice-ages fall into two principal groups: the Simpson group, which postulates changes in radiation emitted by the Sun, and the Milankovich group, which evokes changes in insolation of certain parts of the Earth, especially high latitudes. It is not possible here to examine these theories in detail; suffice it to say that, according to Simpson, temperatures will fluctuate correspondingly in both hemispheres and in all parts of the Earth, whereas according to Milankovich there is no necessary correlation between the hemispheres.

Africa is the only continent straddling the equator where a sufficiently detailed chronology of the pleistocene may be established to test these theories; for human cultures provide probably more sensitive zone-fossils than any biological remains. Very recent researches in West Africa have thrown some light on these problems, and suggest that Alimen's sequence of three and not four pluvials applies not only in the Sahara but also as far as the Guinea coast. Four years ago I began to amass evidence for the Gold Coast[5] of a severe Last Interpluvial corresponding in aridity and in date with the Last Interpluvial of the Congo and South Africa; as in South-West Africa[6], it is not contemporary with but later than the Last Northern Interglacial. There is no clear evidence of an interpluvial within the Second Pluvial, to correspond to the Second Northern Interglacial. So long as this evidence was confined to the coast, though it countered the Simpson type theories, it could be reconciled with the Milankovich type; for greater cold in Antarctica, for which both Milankovich and his successors[7] produce evidence, would intensify the Benguela Current, cool the South Atlantic Ocean, and inhibit rainfall as far as the Gulf of Guinea and over most of the southern part of Africa.

Evidence I have obtained mostly in the last few months from lat. 8–12° N. in the Gold Coast, Togo, Dahomey and especially Nigeria suggests that the Milankovich theory also is untenable. These regions lie north of the Guinea forest and beyond the reach of local marine conditions; their climates should *a priori* be completely northern.

Nearly all the valleys over this area have a similar cross-section. From the gently undulating peneplain there descend very mature slopes. About half-way down, these are rejuvenated with a marked scarp. At the point of rejuvenation there is usually an accumulation of rolled pebbles, and some pebbles are found on the mature slopes, but not as far up as the peneplain. These phenomena have in many cases been dated by artefacts. The rejuvenations belong to the Last Pluvial; the pebble-concentrations mark the valley-bottoms of the Last Interpluvial. Among the pebbles are found numerous rolled pebble-tools, which can scarcely be as late as the Second Pluvial, contemporary with the Chellean and Acheulean cultures. They should belong to the First Interpluvial, and seem to have been dropped on valley-floors about the level where pebbles are observed to start on the mature slopes. There are thus three phases of erosion and two halts, but no indication of an interpluvial during the Second Pluvial.

Table 1

Climatic stage	East African name	Lowland zone: Gold Coast, Togo, Dahomey, Lower Nigeria	Highland zone: Upper Nigeria, ? parts of Togo
First Pluvial	Kageran	—	—
First Interpluvial		Pebble-tools	—
Second Pluvial	Kamasian + Kanjeran	Very little Acheulean	? Chellean, Acheulean abundant
Second Interpluvial		Sangoan	A little Sangoan in Togo only
Third Pluvial	Gamblian	Late Sangoan and probable hiatus	Middle Stone Age
Post-pleistocene dry phase		Very late Middle Stone Age	—

Secondly, from the distribution of cultures in West and South Africa, it appears that during pluvials man was washed out of the valleys and took refuge on the highlands, whereas in the interpluvials he was forced into the less-parched lowlands. The only highlands in West Africa are the Nigerian plateau and parts of the Togo mountains. The distribution of palæolithic cultures is shown in Table 1.

There is no indication of a break during the Second Pluvial or of occupation of the lowland zone. In South Africa there is a minor break at this point. Late Chellean is rare in the Transvaal and abundant in Natal; but it was not arid enough for wind-blown dust to accumulate as it did in the First and Last Interpluvials and in the post-pleistocene dry phase.

Thus it appears that, perhaps as far as 25° N. (according to Alimen), there is a pleistocene sequence of three and not four pluvials, and the Second Pluvial contains a minor dry phase. This sequence cannot be made to correspond with the European glaciations, so the climatic explanations not only of Simpson but also of Milankovich are untenable. The archæologists must now pass the problem back to the meteorologists, and ask them to reconsider it.

O. Davies

University College,
Achimota,
Gold Coast.
May 1.

[1] "Préhistoire de l'Afrique" (see especially, pp. 173, 234).
[2] "Olduvai Gorge"; "Study of Pleistocene Climatic Changes in North-East Angola".
[3] For example, *Problèmes d'Afrique centrale*, 18, 9 (1952).
[4] C.R. Second Panafrican Congress on Prehistory, 293.
[5] *ibid.*, p. 259; *Notes africaines*, p. 65 (1954); and several papers not yet published.
[6] *South African J. Sci.*, 277 (1955).
[7] van Woerkom, in Shapley, "Climatic Change", 147.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 8

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—President's Address—"Fifty Years of Telecommunications" (Jubilee Meeting).

BRITISH ORNITHOLOGISTS' UNION (in the Lecture Hall, British Museum (Natural History), Cromwell Road, London, S.W.7), at 5.15 p.m.—Presidential Report on the Plans for the Centenary of the Union, to be followed by a General Discussion. 6.0 p.m.—Annual Scientific Meeting.

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. G. J. Whitrow: "Some Reflections on the Philosophy of Science of Sir Edmund Whittaker". (Chairman's Address.)

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. E. B. Thomas and Dr. D. Finlayson: "Production and Properties of Cellulose Triacetate".

Tuesday, October 9

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at the Royal College of Science, South Kensington, London, S.W.7), at 10.45 a.m.—Meeting on "Polyphenols in Soils and Plants".

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. E. G. Turner: "The Dead Sea Scrolls and the Hellenistic World".*

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. Denis Taylor: "The Measurement of Radioactivity" (Chairman's Address).

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. A. Stepan: "The Pressure Jet Helicopter".

Wednesday, October 10

PHYSICAL SOCIETY, COLOUR GROUP (in the Lecture Theatre of the Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 3.30 p.m.—Dr. B. H. Crawford: "Lippmann Photography and Interference Filters"; Dr. S. Hesselgren (Sweden): "A Colour Classification System based upon Phenomenological Experiments".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.45 p.m.—Mr. D. M. Ireland: "The Chromatographic Determination of Sugar and Oligosaccharides in Starch Hydrolysates"; Miss Ruth Bennett and Dr. J. B. M. Coppock: "The Natural Ageing of Flour".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the ISLEWORTH GRAMMAR SCHOOL SCIENTIFIC SOCIETY, at the Isleworth Grammar School, Ridgeway Road, Isleworth), at 7 p.m.—Dr. A. E. Werner: "The Scientific Examination of Paintings".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. H. A. Reid: "Sea Snake Research".

Thursday, October 11

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. P. A. Sweet: "The Births and Deaths of the Stars".*

INSTITUTION OF NAVAL ARCHITECTS (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 4.45 p.m.—Dr. J. F. Allan: "Yacht Testing".

Friday, October 12

IRON AND STEEL INSTITUTE (by arrangement with the BRITISH IRON AND STEEL RESEARCH ASSOCIATION, at 4 Grosvenor Gardens, London, S.W.1), at 10 a.m.—"Corrosion" Meeting.

BRITISH MYCOLOGICAL SOCIETY (in the Large Physics Lecture Theatre, Birkbeck College, Malet Street, London, W.C.1), at 11 a.m.—Meeting on "Mycology and Forestry".

BIOCHEMICAL SOCIETY (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 2 p.m.—Scientific Papers.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Opening General Meeting. Presidential Address by Mr. R. C. Thompson.

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Richmond and East Sheen County Grammar School, Park Avenue, East Sheen, London, S.W.14), at 7.30 p.m.—Dr. Norman Booth, Dr. Francis Aylward, Mr. T. McLachlan and Miss Mamie Olliver: "Careers in Chemistry".

SOUTH PLACE ETHICAL SOCIETY (at Conway Hall, Red Lion Square, London, W.C.1), at 7.30 p.m.—Mr. Fred Hoyle: "The Time Scale of the Universe" (47th Conway Memorial Lecture).

Friday, October 12—Saturday, October 13

FARADAY SOCIETY, COLLOID AND BIOPHYSICS COMMITTEE (at the Manson Hall, Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1)—Informal Discussion on "Nucleic Acids and Nucleo-Proteins: Structure and Function".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT, Grade B (graduate, with research or industrial experience), IN CHEMISTRY—The Principal, Derby and District College of Technology, Normanton Road, Derby (October 13).

ASSISTANT LECTURER IN MATHEMATICS—The Registrar, University College of North Staffordshire, Keele (October 15).

LECTURER or ASSISTANT LECTURER IN PURE MATHEMATICS—The Secretary, The University, Exeter (October 15).

SENIOR LECTURER or LECTURER IN EXTRACTIVE METALLURGY, School of Mines and Industries, Adelaide, South Australia—The Agent-General and Trade Commissioner, South Australia House, Marble Arch, London, W.1 (October 18).

RESEARCH CHEMIST (with a first- or second-class honours university degree (or equivalent) in chemistry or biochemistry and satisfactory postgraduate experience in physical or organic chemistry, or biochemistry) IN THE DEPARTMENT OF AGRICULTURE'S PEATLAND EXPERIMENTAL STATION at Glenamoy, Co. Mayo—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (October 19).

ASSISTANT LECTURER (with special interests in the field of historical geography) IN GEOGRAPHY—The Registrar, University College, Singleton Park, Swansea (October 20).

SOIL SURVEYORS with the New South Wales Department of Agriculture, for duties which will include the carrying out of soil surveys in any part of N.S.W., the preparation of data and draft maps from surveys, laboratory work, etc.—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (October 22).

LECTURER IN MATHEMATICS; and ASSISTANTS IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (October 31).

LECTURER IN PHYSICS at Fourah Bay College, Sierra Leone—The Secretary, Advisory Committee on Colonial Colleges, 1 Woburn Square, London, W.C.1 (October 31).

SENIOR LECTURER or LECTURER (preferably with experience and research interests either in the application of modern inorganic and physico-chemical principles to analytical chemistry, or in the field of geochemistry) IN ANALYTICAL CHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

PROFESSOR, SENIOR LECTURERS (2) and a LECTURER, IN THE DEPARTMENT OF CHEMISTRY AND CHEMICAL TECHNOLOGY, University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 8).

LECTURER IN PHYSICS—The Registrar (Room 9, O.R.B.), The University, Reading (November 12).

CHAIR OF CHEMISTRY in Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 13).

LECTURER IN THE DEPARTMENT OF BOTANY at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town, November 15).

LECTURER or ASSISTANT LECTURER IN PHYSICS at Makerere College, University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 30).

ASSISTANT (Grade B) IN THE DEPARTMENT OF MATHEMATICS, Bradford Technical College—The Director of Education, Town Hall, Bradford.

ASSISTANT, Grade B (preferably with an honours degree and teaching, research or industrial experience), IN PHYSICS—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

ASSISTANT LECTURER IN BIOLOGY—The Secretary, Royal Free Hospital School of Medicine (University of London), Hunter Street, London, W.C.1.

ASSISTANT LECTURER (with an honours degree in agricultural botany or botany, and a special interest in plant pathology) IN AGRICULTURAL BOTANY—The Bursar, Royal Agricultural College, Cirencester.

ASSISTANT (preferably with some botanical training) for supervising plots of wheat—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

CHEMIST (honours graduate with at least three years research experience) for studies of the properties of coal extracts and of the halogenation of coals and allied materials—The Assistant Secretary, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey, quoting Ref. C.64.

ELECTRONICS TECHNICIAN, to take charge of a new electronics workshop for constructing and maintaining laboratory equipment—The Registrar, The University, Nottingham.

LIBRARIAN—The Director of Research, British Rubber Producers' Research Association, 48 Tewin Road, Welwyn Garden City, Herts.

PHYSICIST (with an honours degree in physics or equivalent qualification) WITH THE RADIOLOGICAL PROTECTION SERVICE (M.R.C. and Ministry of Health), at Sutton, to carry out special investigations into problems associated with radiological protection, for example, the extent of the hazard involved in the present-day use of ionizing radiations—The Director, Radiological Protection Service, Downs Nursery Hospital, Sutton, Surrey.

PHYSICISTS or PHYSICAL CHEMISTS (with a good honours degree in physics or chemistry, and preferably some research experience) for both fundamental and technological research projects—The Appoint-

ments Officer, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22.

Polymer Chemist, to work on the physical properties of irradiated polymers—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 639/34.

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